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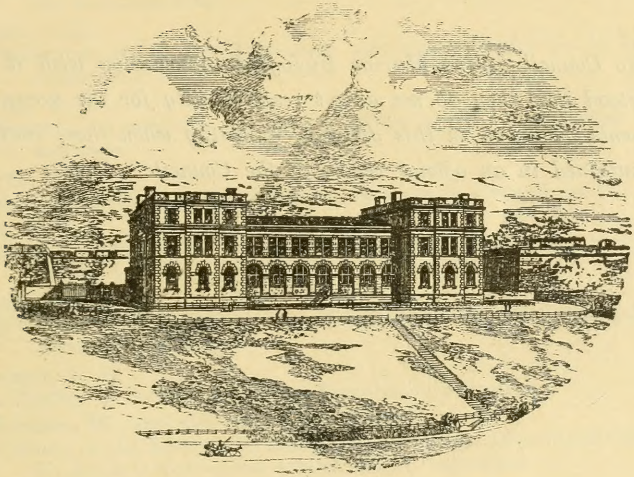

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CONTENTS OF VOLUME X.

(NEW SERIES.)

PAGE

List of Governors, Founders, and Members—
October, 1913 136
May, 1915 656

Report of the Council—
1912 123
1913 395
1914 647
Balance Sheet, 1912 134
ditto 1913 414
ditto 1914 654

ALLEN, E. J.
On the Culture of the Plankton Diatom *Thalassiosira gravida* Cleve, in Artificial Sea-water 417

ALLEN, E. J.
Polychæta of Plymouth and the South Devon Coast, including a List of the Archiannelida 592

BOUVIER, E.-L.
Recherches sur le Développement post-embryonnaire de la Langouste commune (*Palinurus vulgaris*) 179

BOUVIER, E.-L.
Observations nouvelles sur les *Trachelifer*, larves lucifériformes de *Jaxea nocturna* 194

BOUVIER, E.-L.
Quelques mots sur la variabilité du *Pycnogonum littorale* Ström. . . 207

CLARK, R. S.
General Report of the Larval and Post-Larval Teleosteans in Plymouth Waters 327

CRAWSHAY, L. R.
Notes on Experiments in the Keeping of Plankton Animals under Artificial Conditions 555

CRAWSHAY, L. R.
A Method of Separating Sponge Spicules by Filtration . . . 590

DE MORGAN, W., and the late G. H. DREW.
A Study of the Restitution Masses formed by the Dissociated Cells of the Hydroids *Antennularia ramosa* and *A. antennina* . . . 440

DENDY, ARTHUR.
On the Occurrence of *Aphroceras* (*Leucandra*) *cliarensis* Stephens, near Plymouth 258

FUCHS, H. M.
On F_2 *Echinus* Hybrids 464

GEMMILL, JAMES F.
Twin Gastrulæ and Bipinnariæ of *Luidia sarsi* Düben and Koren . . 577

GRAY, J.
The Electrical Conductivity of Fertilized and Unfertilized Eggs . . 50

HARTMEYER, R.
On *Alcyonium pulmonis instar lobatum* Ellis 262

LEIGH-SHARP, W. HAROLD.
Calliobdella lophii Van Beneden and Hesse 81

MORTENSEN, TH.
On the Development of some British Echinoderms . . . 1

PAGE

NICOLL, W.
The Trematode Parasites of Fishes from the English Channel . . 466

ORTON, J. H.
The Ciliary Mechanisms of the Gill and the Mode of Feeding in Amphioxus, Ascidians, and *Solenomya togata* . . . 19

ORTON, J. H.
On some Plymouth Holothurians 211

ORTON, J. H.
On the Breeding Habits of *Echinus miliaris*, with a Note on the Feeding Habits of *Patella vulgata* 254

ORTON, J. H.
On Ciliary Mechanisms in Brachiopods and some Polychætes, with a Comparison of the Ciliary Mechanisms on the Gills of Molluscs, Protochordata, Brachiopods, and Cryptocephalous Polychætes, and an Account of the Endostyle of Crepidula and its Allies . . 283

ORTON, J. H.
Preliminary Account of a Contribution to an Evaluation of the Sea . 312

ORTON, J. H.
On a Hermaphrodite Specimen of Amphioxus, with Notes on Experiments in Rearing Amphioxus 506

RAMSAY, L. N. G.
On *Leptonereis glauca* Clpde., and the Genus *Leptonereis* Kinberg . . 244

REES, OLWEN M.
On *Eloactis mazeli* 70

REES, OLWEN M.
Contributions to the Comparative Anatomy of some British Actiniæ . 521

RITCHIE, J.
Note on Two Unrecorded Plumularian Hydroids from the Plymouth Area 260

SEXTON, E. W.
On *Anthura gracilis* (Montagu) 236

WALTON, CHAS. L.
The Shore Fauna of Cardigan Bay 102

WALTON, CHAS. L.
The Distribution of some Littoral Trochidæ and Littorinidæ in Cardigan Bay 114

WALTON, CHAS. L., and REES, OLWEN M.
Some Rare and Interesting Sea Anemones from Plymouth . . . 60

ZIMMERMANN, K.
Habit and Habitat in the Galatheidea: a Study in Adaptation . . 84

Abstracts of Memoirs recording Work done at the Plymouth Laboratory 513

List of Publications recording the Results of Researches carried out under the auspices of the Marine Biological Association of the United Kingdom in their Laboratory at Plymouth or on the North Sea Coast from 1886-1913 . 143

On the Development of some British Echinoderms.

By

Dr. Th. Mortensen, Copenhagen.

With Figures 1–15 in the Text.

For several years I have felt the desire of going to Plymouth in order to gain practical knowledge of the excellent methods for rearing pelagic larvæ of marine animals, which have been worked out there, especially by the Director of the Marine Biological Laboratory, Dr. E. J. Allen. I was therefore very glad to receive last year an invitation from Dr. Allen to come and stay some time at his laboratory, and having got a grant for this purpose from the Carlsberg Fund and from the Danish Government, I had at length the desired opportunity.

The time I spent in Plymouth—from June 10th to July 15th this summer (1913)—was long enough for learning the methods, but, unfortunately, too short for having the full profit of my rearings, because several of the larvæ take a longer time to reach their full size and still more to pass through metamorphosis. However, the results attained are not unimportant.

No less than six different species of Echinoderms were reared to a more or less advanced stage of development, according to the date at which fertilization could be undertaken, and according to the rate of growth of the different larval forms. These six species are: *Asterias glacialis*, *Luidia ciliaris*, *Ophiactis Balli*, *Ophiocoma nigra*, *Spatangus purpureus*, and *Holothuria nigra*. Fertilization of *Echinocardium flavescens* was also undertaken, but unfortunately the whole culture was destroyed by an accident, and no material was got later on of the species. Some other forms, the development of which I wanted likewise to study, e.g. *Echinocardium pennatifidum*, *Amphiura* (*Ophiocnida*) *brachiata*, *Ophiopsila aranea*, were not ripe at that time or sufficient material could not be got.

The main purpose of these studies on the larval development of different Echinoderms—which I hope to have the opportunity of continuing during a planned voyage to the Pacific—is to find the characteristic features of the larval forms and to see if the larvæ have any bearing on the classification of the full-grown animals. The embryological development in itself is not at present the object of my researches, and in the present report, therefore, only occasionally pure embryological facts are given.

As I had, of course, not much time to study the living larvæ more closely, having so many different cultures going on at the same time, I preserved material of the different developmental stages for study later on. On examining the preserved larvæ after my return to Copenhagen I found that a very regrettable mishap had occurred. The alcohol in which the larvæ were kept had in some way or other become acid, and the skeleton of all the larvæ had been dissolved. As the specific characters are especially found in the skeleton in those larvæ which are provided with such, the value of my material had thus been considerably diminished. Fortunately I had made a preparation in Canada balsam of the larva of *Ophiactis Balli* while still in Plymouth, so that in this case nothing was lost.

After I left the laboratory my cultures were looked after for some time by the attendant, Mr. Smith, and some of the later stages were sent me. In this way I got the later stage of the *Luidia* larva ; a few larvæ of *Spatangus purpureus*, with the skeleton preserved, also came to hand, but in so poor condition that only little use could be made of them. Of the other larvæ only a few of *A. glacialis* were obtained, but these were not in a more advanced stage than that reached before I left the laboratory.

I.—**Asterias glacialis.**

The development of this species has never been satisfactorily worked out, in spite of the fact that it is one of the objects commonly used in experimental embryology. A. Russo, in his paper "Contribuzione all' embriologia degli Echinodermi e sviluppo dell' Asterias glacialis O. F. Müller,"* describes the first developmental stages, until the formation of the vibratile chord. Having reached this stage the larvæ began to degenerate. Some later stages, which were caught pelagically, were also referred by Russo to this species (his figures 22–25) ; it is, however, evident enough that they cannot belong to this species—the strong development of the vibratile chord at the anterior end of the frontal (or preoral) area, where the brachiolarian processes appear later on in the *Asterias* larva, is sufficient proof that they cannot belong to an *Asterias*. In my *Echinodermenlarven der Plankton Expedition* (p. 30), I have given the name *Bipinnaria Russoi* to this larva. The rearing of the more advanced stages of the *A. glacialis* larva has given the definite proof that

* *Boll. d. Soc. di Naturalisti in Napoli*, Ser. 1, Vol. VII (1892).

I was right then in maintaining that these later stages figured by Russo could not belong to *A. glacialis*.

The most important and interesting contribution to the development of *A. glacialis* has been given by Yves Delage, who has reared *parthenogenetic* larvæ of this species to full size and beginning metamorphosis.* In spite of this it is still very desirable to make further studies of the normal development of this species. One can, of course, not be sure beforehand that the parthenogenetic larvæ are quite like those normally developed. Further, the figures given by Delage are partly not very satisfactory. In fact, it still remains uncertain what the specific characters of this larva are, by which it may be distinguished from other *Asterias* larvæ, or whether, perhaps, such characters do not exist, so that this larva could not be distinguished with certainty from other *Asterias* larvæ, for instance that of *A. rubens*.

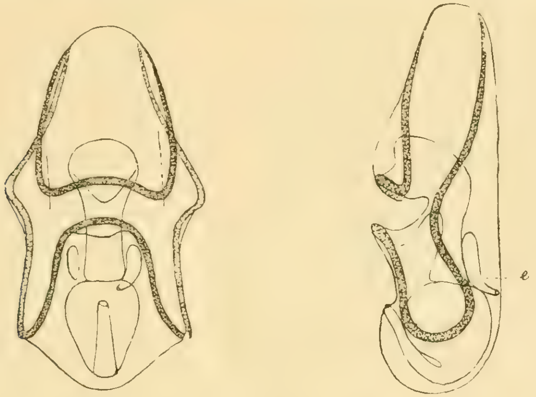

Fig. 1. Fig. 2.

FIGS. 1–2.—*Bipinnaria* of *Asterias glacialis*, seven days old. 1, front view; 2, side view; *e*, enterocœl vesicle. 100/1.

I was very glad then to have the opportunity already on the second day (the 12th June) after my arrival at the laboratory of making an artificial fertilization of *A. glacialis*. The fertilization was very successful, about 95 per cent of the eggs being fertilized. The culture went on excellently, the larvæ being fed with the diatom *Nitzschia* from Dr. Allen's cultures. However, I did not succeed in obtaining the fully developed larval form. Delage found that the rate of growth of his parthenogenetic larvæ was comparatively slow, and I had the same experience with the normal larvæ.

The differentiation of the vibratile chord began after five days, and after seven days (the 19th) the stage represented in Figures 1–2 was reached. For the next two weeks there was no further differentiation, and I nearly gave up the hope of getting it to proceed in its development, thinking that the diatoms were perhaps not suitable food for this larva; indeed, I found that the diatoms ejected by it had the same colour as those which had not been swallowed, so it appeared that the larvæ could not digest the diatoms. But on the 4th July I found some specimens in which the left enterocœl vesicle had begun to grow forwards, and now the development went on continually. On the 7th July the enterocœl vesicles had united in the preoral lobe, and the long processes had begun to develop. The stage represented in Figures 3–4 was reached on the 9th July. When I left Plymouth, on the 15th, no essential advancement beyond this stage could be observed, and a few larvæ sent to me later on were not in a more advanced stage either. I am thus unable to give definite information of the specific characters of the fully developed larva.

---

* Yves Delage, "Élevage des larves parthénogénétiques d'*Asterias glacialis*" (*Arch. de Zool., expér. et gén.* (4), II, 1904, pp. 27–46.)

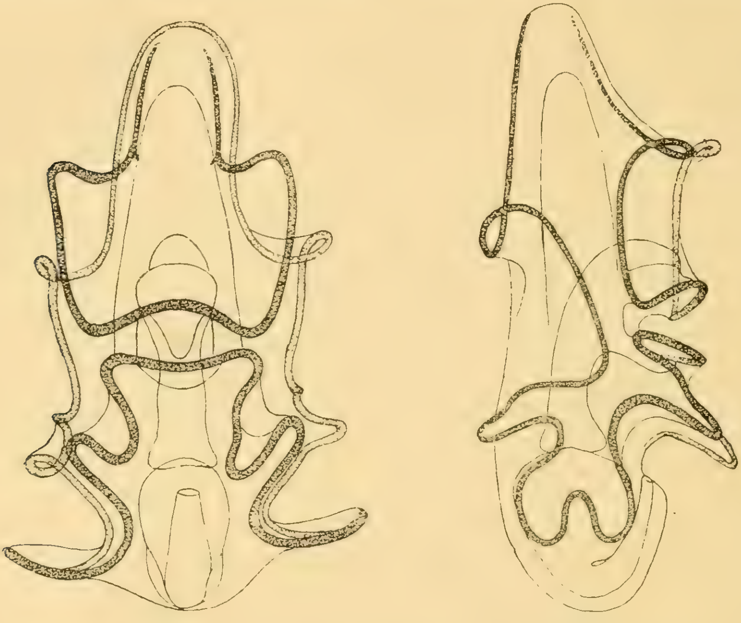
Fig. 3. Fig. 4.

FIGS. 3–4.—*Bipinnaria* of *Asterias glacialis*, four weeks old. 3, front view; 4, side view. 80/1.

Judging from the figures given by Delage, the larva of *A. glacialis* differs from the larva of *A. rubens* and *vulgaris*, the only two other species known to which it is similar, in the sucking disc at the basis of the brachiolarian processes being surrounded by a complete ring of small papillæ, while in the two other species there are only 2–3 papillæ at each side of it (cp. text Figs. 4–6 of Delage's paper). Also the crown of the brachiolarian processes appears to afford a good specific character, there being 2–3 circles of small papillæ on a thickened ring, while in the other species there is only a single circle of papillæ at the tip and no thickened ring. If this proves to hold good for the normally developed larva of *A. glacialis*, it will be easily distinguishable from the other species. A number of larvæ which were taken in the Plankton at Plymouth all had only 2–3 papillæ at each side of the disc, and the crowns consisting of a single circle of papillæ ; they should accordingly all belong to *A. rubens*, which may be possible, since also some few ripe specimens of this species were found. In any case, it is very desirable to have the *A. glacialis* larva reared to its full size, so that we may be able to see, with certainty, by which characters it differs from the *A. rubens* and *A. vulgaris* larvæ. As the species *A. glacialis* is not so very closely related to the other two species mentioned, one would expect the larvæ likewise to be distinct enough.

In the *Echinodermenlarven der Plankton Expedition* (p. 43), I have distinguished, under the name of *Bipinnaria lævis*, an *Asterias* larva found by Joh. Müller at Elsinore, which differs from the *A. rubens* larva in having no dorsal median process. I suggested that this larva might belong to *A. glacialis*, as there are found only three *Asterias* species in the Sound (between the Kattegat and Baltic), i.e. *A. rubens*, *Mülleri* and *glacialis*, the latter being, however, very rare here. The larvæ reared by Delage would seem to show that the dorsal median process is as well developed in the *Bipinnaria* of *A. glacialis* as in those of *A. rubens* and *vulgaris*, and then the *B. lævis* can only be an abnormal larva of *A. rubens*. I have never observed such specimens among the numerous larvæ of this species which I have seen.

The culture of the *A. glacialis* larvæ showed the interesting feature that a large number of the larvæ, about 50 per cent of them, had either two dorsal pores, one for each enterocœl vesicle, or the vesicles were united across the stomach, having one single, median pore (Figures 5–6). This feature has also been observed by Goette* in the larva of the same species. G. W. Field, in his paper "The Larva of *Asterias vulgaris*" † (pp. 110–111), describes the formation of two pore canals in the young *A. vulgaris* larva as a normal feature, while the presence of two pore canals has otherwise been regarded as pathological. Field found the two pores persisting only a short time, the right being closed again 8–12 hours after its formation. Though I have not paid attention to this on examining the living larvæ, I think I can say definitely that the formation of two pore canals is not a normal process in the larva of *A. glacialis.* In the larvæ which I preserved on the 16th June, at 9 p.m., the enterocœl vesicles have not been formed; in those preserved on the 17th, 10 a.m., they are formed, and the left vesicle alone has a pore. It is certainly very improbable that the pore of the right vesicle should then already have disappeared completely; this process would in that case go much faster than Field has found it in *A. vulgaris.* It seems to me that the facts here produced rather tend to show that what Field has found is an abnormality. In any case the two pores in the *A. glacialis* larva represent an abnormality. To enter on a discussion of the possible phylogenetic importance of the two dorsal pores is not the place here.

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* Goette, "Bemerkungen zur Entwicklungsgeschichte der Echinodermen" (*Zool. Anzeiger*, 1880, p. 324. Fig. 2).

† *Quart. Journ. Micr. Sci.*, N.S., 34, 1893.

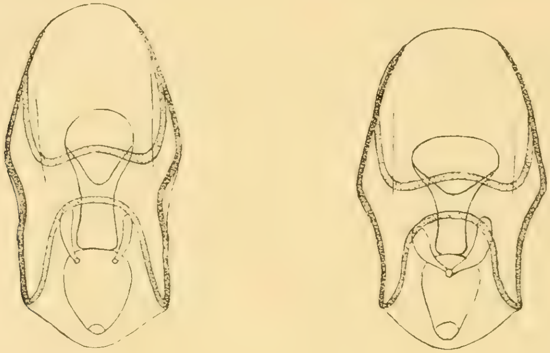

Fig. 5. Fig. 6.

Figs. 5–6.—*Bipinnaria* of *Asterias glacialis,* showing abnormal formation of dorsal pores. Seen from the dorsal side. 100/1.

I must also mention the observation that the larvæ of this species, as well as of all the other species reared, in swimming rotate around their longitudinal axis, always turning to the left. In the *Spatangus* and *Ophiactis* larvæ this rotation ceases along with the development of the long processes; in the other larvæ it had not ceased in the most advanced stages observed.

II.—**Luidia ciliaris.**

This species at first caused me a good deal of trouble. Both females and males were found with ripe genital products, but the spermatozoa did not move. Being myself not familiar with experimental work on fertilization, I asked Mr. J. Gray, who was working at the laboratory, for advice. He suggested that we might try to raise the alkalinity of the water by adding some drops of sodium hydroxyde (NaOH). This proved excellent. The spermatozoa at once began to move, and then the fertilization succeeded completely. It was already at a rather late point of time, the 27th June, so that it could not be expected to get the complete development of this species; still a good deal was reached, and as this is the first time a *Luidia* has been reared, the observations are of some interest.

The cleavage is unequal, the relative size of the two first cleavage cells being, however, somewhat variable. The blastula has the same remarkable character as is described by Masterman for *Henricia sanguinolenta*,[*] and by Gemmill for *Solaster endeca*,[†] the cell layer forming irregular folds. The gastrula is rather elongate and large; this stage is reached on the third day. After five days the larvæ begin to assume the shape of small Bipinnariæ (Fig. 7); the enterocœl vesicles have formed, but the vibratile chord is not yet differentiated at the anterior end. The next day, the 3rd July, the vibratile chord was complete (Fig. 8). The most advanced stage to which the larvæ reached before I left Plymouth is represented in Figure 9, from the 14th July. The processes have begun to appear, and the preoral lobe has begun to assume the characteristic elongate shape of the *Luidia* larva; the enterocœl vesicles have united in the preoral lobe.

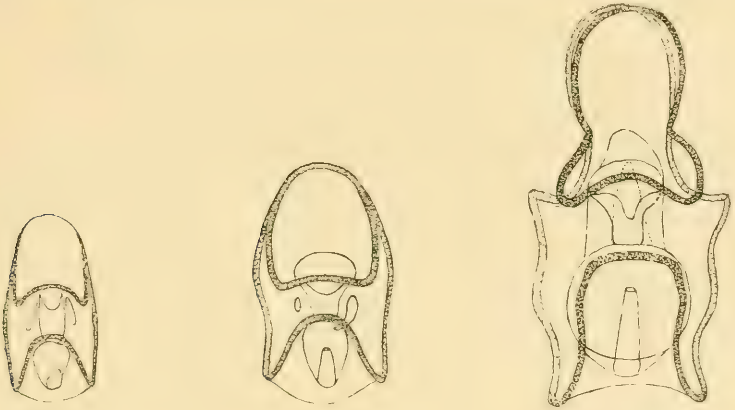

Fig 7. Fig. 8. Fig. 9.

Figs. 7–9.—*Bipinnaria* of *Luidia ciliaris*. 7, five days old; 8, six days old; 9, eighteen days old. Front view. 100/1.

After my return to Copenhagen I had the pleasure to receive a couple of larvæ from the same culture, preserved by Mr. Smith, on the 1st August, being thus a little over one month old. They are represented in Figures 10–11. Here the shape of the *Luidia* larva, so characteristic through the elongated preoral part and the long median processes, is easily recognized. The length of the larva is now 1 mm. Still the development is not sufficiently advanced for showing definitely by which characters this larva is distinguished from the Bipinnaria of *Luidia sarsi*. But it can now scarcely be doubted that the larva figured by Garstang, in his paper " On some Bipinnariæ from the English Channel,"* is really the larva of *L. ciliaris*. This species is very common at Plymouth, while *L. sarsi* is rare ; its breeding season is June to July, and Garstang found the larva in August. I have previously held the opinion that Garstang's larva belonged to *L. sarsi* ;† I must now join Ludwig‡ in the opinion

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[*] A. T. Masterman, "The early development of *Cribrella oculata* (Forbes), with remarks on Echinoderm development" (*Trans. R. Soc. Edinburgh*, Vol. XL, 1902). See especially Plate I, Fig. 17.

[†] James F. Gemmill, "The development of the starfish *Solaster endeca* (Forbes)" (*Trans. Zool. Soc., London*, XX, 1912).

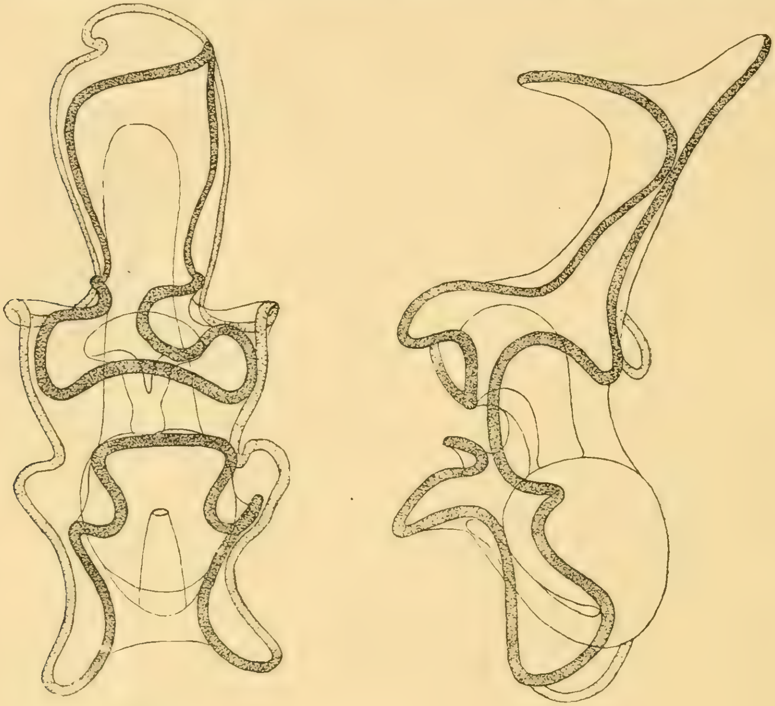

Fig. 10. Fig. 11.

Figs. 10–11.—*Bipinnaria* of *Luidia ciliaris*, five weeks old ; 10, front view ; 11, side view. 100/1.

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* *Quart. Journ. Micr. Sci.*, N.S., 35, 1894.

† *Echinodermenlarven der Plankton Expedition* (p. 40). *Nordisches Plankton Echinodermenlarven* (p. 11).

‡ H Ludwig, " Der Asteriden des Mittelmeeres." *Fauna u. Flora d. Golfes v. Neapel*, 24 Monogr., 1897 (p. 82).

that it belongs to *L. ciliaris.* It is, however, still very desirable that this larva should be reared to metamorphosis—and as it has now been found to be easily reared, this will probably soon be done—this large, beautiful larva must, indeed, be a magnificent object for embryological study.

In the *Echinodermenlarven der Plankton Expedition* (pp. 39–40), I have remarked, in connection with the suggestion made by Hensen that the young larvæ might be fixed, that this conclusion is scarcely justified, because the young larvæ have not yet been found. To this remark Hensen has added the following note (p. 40): "Meine Æusserung lautet: 'Die I. Fahrt brachte 114, die II. 11, und die III. 78 Luidien mit Stern, in Summa 203, deren Diagnose wir Hrn. Mortensen verdanken. Es müssen doch wohl die jüngeren Larven eine festsitzende Lebensweise haben, sonst könnten sie uns nicht entgangen sein.' Da Zahlen beweisen, muss ich an diesem Satz festhalten." Though I have always been quite convinced that the *Luidia* larva could not have a fixed stage before the free-swimming larval stage, it is quite satisfactory for me that I have now been able to give the definite proof that my opinion, founded on morphological grounds, was right, in spite of Hensen's statistics. To be sure, my observations are made on *L. ciliaris*, while Hensen speaks of *L. sarsi:* but to suppose that of two so very similar larvæ one should be fixed in its first stages, the other free-swimming, would really be too absurd.

It is very remarkable that the larvæ of *L. ciliaris* appear to be comparatively rare at Plymouth. Being impressed with the enormous development of the gonads in this species I have tried to make an approximate calculation of the number of eggs in a large *L. ciliaris.* In a specimen of 30 cm. arm length I counted the number of gonads—which are here arranged in a series along each side almost to the point of the arm instead of one large gonad at each side of the basis of the arm as is the rule in Asteroids—and found them to number 150 in each series—300 per arm. As the species is seven-rayed, a complete* female of that size, which is nearly the average, has 2,100 ovaries; these are, however, of somewhat different size, decreasing in size towards the point of the arm. An ovary from about the middle of the arm was divided into a hundred parts of as nearly as possible equal size, and the number of eggs in one part was counted; it was ca. 3,000. This means that in one ovary there are at least ca. 300,000 eggs, probably nearer half a million. Taking, however, into consideration the decreasing size of the ovaries towards the point of the arm it may be just to take as the mean number of eggs per ovary only 100,000, and for safety we may still reduce the number of ovaries to 2,000. This gives as the number of eggs in a grown female of *L. ciliaris* no less than 200 millions. We might expect from this that this species would be exceedingly common, the larvæ as well as the grown. But the larvæ are only rarely observed, and as for the grown specimens, one may certainly expect to get about half a dozen specimens in each haul with the trawl, and from their large size this makes the impression of a good lot—in reality this is a very small number, especially compared with *Ophiocoma* and *Ophiothrix*, which are generally taken by thousands in each haul. What a waste of eggs must here take place !

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* The arms very easily break off, and it is quite difficult to get complete specimens, though such are often seen in the contents of the trawl, before it is hauled on deck.

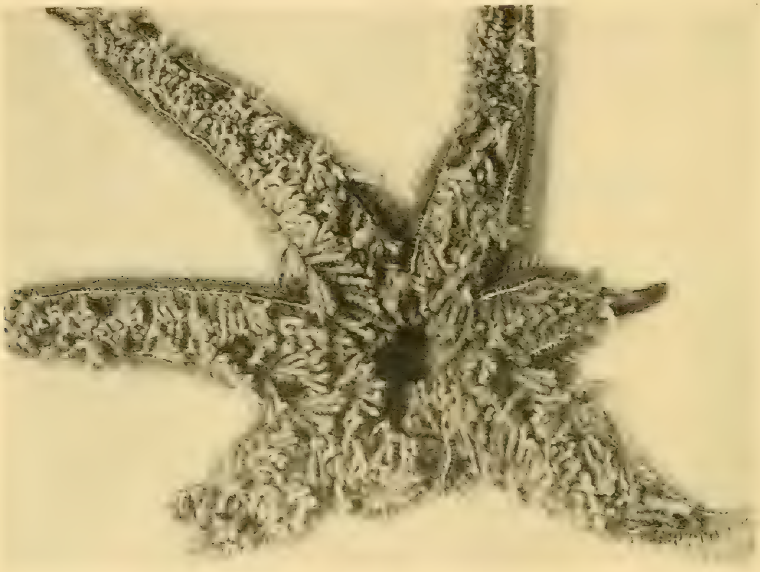

Fig. 12.

FIG. 12.—Female *Luidia ciliaris*, opened so as to show the genital organs. ¼ of natural size. (From a photograph by Mr. F. Martin Duncan.)

In Figure 12 is represented a female of *L. ciliaris* opened so as to show the gonads. It gives, however, only a slight impression of the profusion of gonads seen in such a specimen, the more conspicuous on account of the beautiful red colour of the gonads with the ripe eggs.

I may here mention that in this species a distinct sexual dimorphism may be observed, at least in the breeding season. The colour of the female is red, that of the male brownish; the rays of the female are somewhat broader than in the male, and upon the whole the male scarcely reaches so considerable a size as the female. It is mostly quite easy to distinguish between the sexes at a glance—quite apart from the fact that generally the arms break so as to expose some of the gonads.

In the stomach of this species I have found remnants of Ophiurids (*Ophiothrix*).

III.—**Ophiactis Balli.**

On the 17th June several specimens of this species were taken on the Eddystone grounds, especially on tubes of *Chætopterus* and on Ascidians. Some of these were found to contain ripe sexual products; they were placed in a large jar with only a few centimetres of water, in order to try if they would shed their eggs and sperm. Already next day I had the pleasure of finding the fertilized eggs, which had partly already reached the blastula stage; at 12 o'clock, viz. after scarcely more than eighteen hours, the first swimming blastulæ were observed. On the 19th the embryos were found swimming actively close to the surface of the water; they were somewhat elongated, a little transparent at one end. On the 20th the first rudiments of the skeleton were formed, and the postero-lateral processes had begun to appear, showing already an indication of red colour at the point. On the 21st the larvæ had already distinctly the shape of an *Ophiopluteus;* the antero-lateral and the postoral rods (and processes) had begun to grow out, and likewise the recurrent rod had begun to appear. On the 26th the body skeleton was completely formed, and the three pairs of processes had become somewhat longer, especially the postero-lateral. These latter processes are distinctly red at the point; also the postoral transverse chord has a reddish tint, the larva being otherwise uncoloured. It always swims near the surface, but at this stage does not any longer rotate round its longitudinal axis.

Having reached this stage the development ceased; the larvæ still remained alive for some days, but without showing further advance. Probably the diatoms were not suitable food for them. However, the stage reached is sufficiently advanced for showing the characters of the larva, so that it will be possible to recognize it also in later stages, the essential characters of the Ophioplutei lying in the body-skeleton, which had, fortunately, already reached its full development (Fig. 13).

The main features of it are the following: Recurrent rods are present, whereby two large meshes are formed in each half of the body. The cross-rods are peculiar in being slightly lobed at the end, the lobes of the two rods of each side catching into each other. The end-rods are rather long, straight, trifid at the point. The postero-lateral rods are provided with thorns along the inner side, and also the antero-lateral rods are slightly thorny. (These thorns will doubtless be considerably more numerous in the fully developed larva.) It must be pointed out that there is no posterior tuft of cilia; the frontal area is quite small. Otherwise there is nothing to be remarked concerning the shape of the larva, in this stage at least; it has the typical *Ophiopluteus* shape, as appears from the shape of the skeleton.

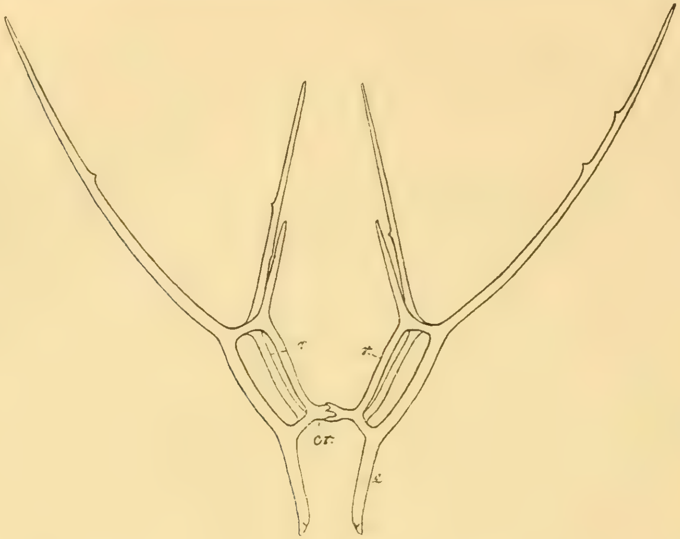

Fig. 13.

FIG. 13.—Skeleton of the *Ophiopluteus of Ophiactis Balli*. *cr*, cross-rod; *e*, end-rod; *r*, recurrent rod. 275/1.

It is very satisfactory that the larva of this species could be reared to a sufficiently advanced stage for recognition, this being the first information of the larval form of a species of the genus *Ophiactis*. (The two species *Ophiactis Kröyeri* (L.) and *O. asperula* (Phil.) appear to be viviparous.*)

IV.—**Ophiocoma nigra.**

It was not until towards the end of June that this species was found to contain ripe sexual products. On the 25th June some specimens were put in a jar in the same way as *Ophiactis*, and the next day some fertilized eggs were found. It was no large number, and I then repeated the experiment, but without success, evidently because the specimens were not very ripe. To open the specimens and take out the eggs did not prove good either for the same reason. However, some results were obtained from the eggs got at the first experiment. The development proved to be comparatively slow. The first indication of the postero-lateral processes was found on the 30th, i.e. in ca. five days old embryos. The embryos are remarkably elongate, and the oral lobe remains very large after the formation of the said processes. On the 1st July I found the first rudiments of the skeleton. On the 4th July there was seen the first indication of the postoral rod, and the postero-lateral processes had somewhat increased in length—but herewith the development apparently ceased ; the larvæ were alive and apparently healthy when I left on the 15th July, but the development was not advanced beyond the stage reached on the 4th. Probably again the food was not suitable.

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* H. Ludwig, "Brutpflege bei Echinodermen." *Zool. Jahrbücher*, Suppl. VII, 1904, p. 693.

The development reached a sufficiently advanced stage to show that the body skeleton is simple, without recurrent rod. The cross-rods are thorny. The body skeleton is upon the whole small, the rods short. Unfortunately I can give no figure of it, the skeleton having been dissolved in all the preserved specimens as explained above. The colour is yellow, or at the point of the postero-lateral processes, yellowish green : there is no indication of red pigment.

Though the rearing of this larva was thus not very successful, the results obtained are not without value ; from the indications given here it will doubtless be possible to recognize the *Ophiocoma* larva, when it is found in the plankton. The two Ophiurids, *Ophiothrix fragilis* and *Ophiocoma nigra*, are by far the most numerous Ophiurids occurring at Plymouth ; they must almost cover the bottom on large areas. The larvæ of both forms must occur in large numbers in the full breeding seasons of the two species. As the larva of *Ophiothrix* is well known, it must be possible to find out, with the help of the indications given here, which larva belongs to *Ophiocoma*, and in all probability the larva is already known. In a paper on Loch Sween ("The Glasgow Naturalist," *Journ. Nat. Hist. Soc. of Glasgow*, IV, 1912) Professor J. Graham Kerr has figured (p. 43, Fig. 4) a very peculiar Ophiurid larva, which agrees with the *Ophiocoma* larva in having a simple body skeleton and a very large preoral lobe. It occurred in immense numbers at the beginning of August—the season thus being likewise in accordance with the suggestion that it is the *Ophiocoma* larva. In fact, Graham Kerr himself gives that suggestion, and I think it very probable that he is right. The most conspicuous peculiarity of this larva is the development of four "epaulettes," as I have previously found in a larva from the Bermudas described as *Ophiopluteus Henseni* in the *Echinodermenlarven der Plankton Expedition* (p. 62, Pl. VII, 2). The occurrence of a similar—though quite distinct—larva at the Bermudas is not at all against the supposition that the larva figured by Kerr belongs to *O. nigra*, since this genus is also represented at the Bermudas (by the species *Ophiocoma echinata* (Lmk.) and *O. pumila* (Ltk.).

This larva has also been observed at Port Erin by Dr. H. C. Chadwick, who showed me on my visit there (at the end of July) figures he had made of these and many other Echinoderm larvæ. May we hope that he will soon publish his many beautiful figures and interesting observations on the Echinoderm larvæ? They would doubtless prove of great value to students of these larvæ, which are so interesting from both a morphological and a biological point of view. Even if the larvæ can at present only partly be referred to species, they are, at least most of them, so well characterized that they can be recognized with certainty, and the observations made on the larvæ of hitherto unknown origin are by no means lost, but may be directly transferred to the species to which some such larvæ are later on proved to belong.

V.—**Spatangus purpureus.**

This species is one of the very first Echinoderms of which artificial fertilization and rearing of the larvæ were undertaken. It was A. Krohn who did so in Messina in 1853 ("Über die Larve von *Spatangus purpureus*," *Müll. Arch.*, 1853, p. 253, Taf. VII). He did not succeed in rearing it to metamorphosis, but still so far that he thought he was able to recognize it in free-swimming specimens. In another paper, "Beobachtungen über Echinodermenlarven" (*ibid.*, 1854, p. 208), he gave them some further observations on the structure of this larva, from which it appears that it is characterized especially by the postoral, postero-dorsal, and posterior rods being fenestrated only in their outer part, a considerable portion at their basis remaining unfenestrated; further the postero-lateral processes ("auricularfortsätze") are "äusserst kurz, breit und abgerundet." In my *Echinodermenlarven der Plankton Expedition*, as well as in *Nordisches Plankton* I have accordingly given these characters for this larva, no later observations having been made on it. The observations of Krohn are, however, not very detailed, and especially it is an important objection that the reared larvæ did not reach a very advanced stage. There must be several other Spatangoid larvæ in the Mediterranean, and as their specific characters are not sufficiently known we have no guarantee that the pelagic larvæ which Krohn referred to *Spatangus purpureus* did really belong to that species. It was therefore very satisfactory to me to get the opportunity of rearing the larva of this species during my stay in Plymouth. It proved to be very easy to rear; the larvæ developed normally and reached their full size in the course of three weeks. The fertilization was made on the 23rd June; on the 14th July the larvæ had all their processes developed, and the first sign of the metamorphosis (formation of the oral disc) had appeared. Unfortunately I cannot utilize this culture for a complete description of the larval skeleton, on account of the mishap explained above. Still some notes can be given which may prove sufficient for the certain recognition of the larva.

The shape of the fully formed larva is, as shown in Figure 14, that of the typical Spatangoid larva. It is especially to be noticed that the postero-lateral processes are long and slender (and a little posteriorly directed) as in other Spatangoid larvæ, not short, broad, and rounded as stated by Krohn. If it is, upon the whole, really the *S. purpureus* larva which Krohn has observed, it must then have been in a stage where the postero-lateral processes are just about to appear. According to his description, "Beobachtungen über Echinod. larven," p. 209, quoted in *Echinodermenlarven der Plankton Expedition*, the body shape of the larva is rather complicated, with lobes and folds; in reality it is quite simple, without folds, as seen in the figure. It is, then, most probable that the larva described here by Krohn is not at all the *S. purpureus* larva, but the larva of another Mediterranean Spatangoid—which species cannot be ascertained at present. The only thing in the description of Krohn which agrees with the *S. purpureus* larva is the extraordinary length of the postoral, postero-dorsal, and, especially, the posterior processes. Very probably also the other processes will attain a greater length than shown in the figure. They are a little swollen at the point, which is conspicuously coloured with red pigment. A feature to be noticed about the larva is a groove inside the posterior transverse chord (Fig. 14); the meaning of this groove is unknown to me.

The skeleton is, as shown by Krohn, characterized by the fact that the fenestrated rods (postoral, postero-dorsal, and posterior) have no holes in their basal part; in the posterior rod it is, however, only quite a short part which is unfenestrated (Fig. 15), in the other rods the unfenestrated part may really be as long as figured by Krohn ("Über die Larve von *Spatangus purpureus*," Taf. VII, 2–3); characteristic also is the widened basal part of the antero-lateral rods (cf. Krohn, Taf. VII, 5). The most important point to settle in regard to the skeleton is the structure of the postero-lateral rod, which appears to be the part of the skeleton of the Spatangoid larva which affords the best specific characters. Unfortunately the only information I can give of it is that to be found in

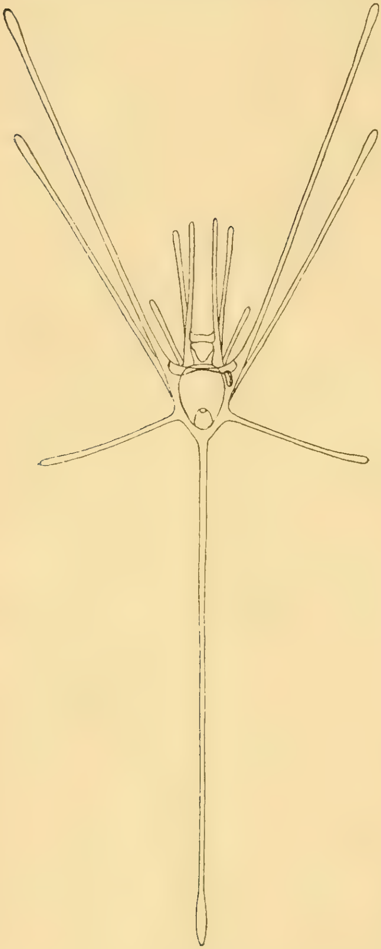

Fig. 14.

Fig. 14.—*Echinopluteus* of *Spatangus purpureus*, three weeks old. 35/1.

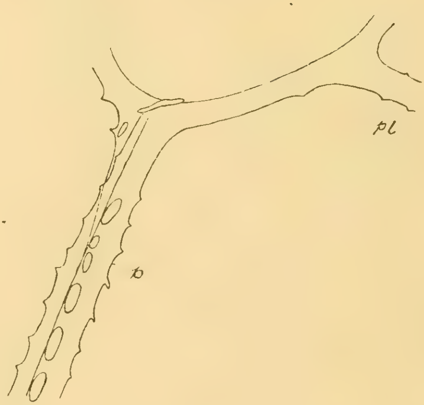

Fig. 15.

Fig. 15.—Part of the skeleton of the *Echinopluteus* of *Spatangus purpureus*. *p*, Posterior rod. ; *pl*, postero-lateral rod. 275/1.

Figure 15. It is seen that its basis is not widened, and that its edges are serrated. Apparently it will be found to resemble that of the larva of *Echinocardium cordatum* (cp. *Echinodermenlarven der Plankton Expedition*, Taf. IX, 7).

The total length—processes included—is ca. 3·5 mm., not 6 mm. as

Krohn gives it (*op. cit.*, p. 209). It may be mentioned that from the appearance of the first processes, the posterior and postoral, it ceases rotating round its longitudinal axis. The first appearance of the postero-lateral processes occurred on the 7th July, viz. in the two weeks old larva ; the antero-dorsal processes are the latest to appear—when the metamorphosis is beginning, in ca. three weeks old larvæ.

All processes, except the preoral, have a conspicuous red point; otherwise there are scattered red pigment cells on the body and processes, more numerous on the body and the posterior process, and at the frontal edge.

VI.—**Holothuria nigra.**

The development and the larval form of this species being hitherto quite unknown, I was very anxious to try fertilizing and rearing it. Ripe specimens were found together with such as were very far from having ripe sexual products. The difficulty was with the eggs ; I never found a specimen with the eggs quite ready for fertilization. The nucleus was nearly always large, and while in the other Echinoderms used by me for fertilization the eggs were found to ripen after having been some hours in sea-water (the nucleus disappearing), this was not the case in *Holothuria nigra;* even after the eggs had been twenty-four hours or more in the sea-water only in quite a small percentage of them had the nucleus disappeared. The eggs are a beautiful red, with a radiating striated membrane, as is known in other Holothurians.

On the 24th June I tried fertilization, having found a female in which more eggs than usual had no visible nucleus. (Ripe males were easy to get.) The fertilization was, contrary to my expectations, successful; on the next day I found that ca. 200 eggs were apparently in cleavage—but the cleavage looked so irregular that I was nearly certain the development was not going on normally. However, these eggs were isolated, and on the 27th I found that they had developed into swimming gastrulæ. On the 1st July the vibratile chord had begun to differentiate, and on the 4th July they had developed into a typical *Auricularia, with a star-shaped spicule at the posterior end.* Beyond this stage the development had not proceeded when I left Plymouth, and as I had only very few larvæ left, I could not get material of it preserved later on. It appears from this that there will be no difficulty in rearing the larvæ of this species, contrary to Selenka's experiences with *Holothuria tubulosa* (" Zur Entwicklung der Holothurien. [*H. tubulosa* und *Cucumaria* *doliolum.*] Ein Beitrag zur Keimblättertheorie," *Z. w. Zool.* XVII, 1876). The difficulty here is to get the eggs in condition for fertilization.

The *Auricularia* of *H. nigra* very much resembles that of *H. tubulosa*, as figured by Selenka (*op. cit.*, Taf. X, 9). The colour is the same as shown there, only I find it more equally distributed in the vibratile chord; also there are some patches of this colour over the body, and especially in the posterior end. Unfortunately I did not make a drawing from a living specimen; the few preserved specimens are not so well preserved that it would be worth giving a figure therefrom, and the spicule has been dissolved. Still, the information given here will be quite sufficient for recognizing the larva, especially in the waters off Plymouth, where no other *Holothuria* species occurs with which it could be confounded.

Judging from the larva, *H. nigra* must be nearly related to *H. tubulosa*. The suggestion made in my *Echinodermenlarven der Plankton Expedition* (p. 15), that the larva of *H. tubulosa* will prove to have a spicule at the posterior end in later stages, is very much supported by the fact that such a spicule is found in the larva of *H. nigra*. A similar calcareous spicule is also found in *Auricularia stelligera* (Joh. Müller's "Auricularia mit Kugeln"); but it has besides some pink elastic spheres, of which there is no indication in the larvæ of *H. nigra* and *tubulosa*, so that the *A. stelligera* would not seem to be very closely related to these larvæ.

The Ciliary Mechanisms on the Gill and the Mode of Feeding in Amphioxus, Ascidians, and *Solenomya togata.*

By

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With Figures 1–11 in the Text.

TABLE OF CONTENTS.

	PAGE
Introduction	19
The Mode of Feeding in Amphioxus	20
The Ciliary mechanisms on the gill of Amphioxus	22
The Ciliation of the Endostyle	24
The function of the Wheel Organ and the peri-pharyngeal bands in Amphioxus	25
Recapitulation of the account of the food and respiration currents in Amphioxus	27
The function of the Pharynx in Amphioxus	28
The Mode of Feeding in Ascidians	30
Food-collection in various Ascidians	31
Ciliary mechanisms on the gill of Ascidians	33
Comparison of the Mode of Feeding in Amphioxus and Ascidians	35
The Function of the gland and its ciliated tract in the Branchial Openings of Amphioxus and Ascidians	36
The Maintenance of the Pharyngeal spaces in Ascidians and Amphioxus	37
The Ciliation of the gill of Balanoglossus	37
Observations on the Ammocoete of *Petromyzon fluviatilis*	38
The Mode of Feeding in *Solenomya togata*	38
The ciliation of the gill of Solenomya	40
Resemblance of the ciliation of the gill in Solenomya and Nucula	43
Summary of the account of the ciliary currents in Solenomya	44
The function of the gill in Lamellibranchs	44
Appendix	45
Summary	47

INTRODUCTION.

It is well known that Amphioxus obtains its food by straining off the nutritive particles contained in the current of water which is taken in continuously at the mouth and expelled at the atriopore. It is also well known that the cilia on the gill cause this continuous current, and that in some way a separation of the food-particles is effected.

The existing explanations, however, of the manner in which these two processes are effected are either very vague or only partially true and misleading. It is to clear up our ideas on this matter that the present account is written.

It is generally stated that the current through the pharynx of Amphioxus is effected by the cilia on the gill-bars, and that the food-particles are collected in the endostyle which conducts them forwards to the peripharyngeal bands (1, 2, and 3). The latter are then described as conducting the collected food to the dorsal groove, which in turn conducts it backwards to the intestine. These statements are vague and wrong and misleading, inasmuch as there are on the gill-bars at least two sets of cilia which function in quite different ways, and the endostyle does not conduct food-particles forwards, as will be seen from the following description :—

MODE OF FEEDING IN AMPHIOXUS.

While the animal is at rest a current of water is being taken in continuously at the mouth and expelled at the atriopore. This current serves for the nourishment of the animal, and doubtless is also a main factor in its respiration. If an Amphioxus[*] be placed in water containing fine particles of carmine in suspension or in water containing diatoms and dissolved methylene blue, a mass of particles embedded in mucus very soon collects in the dorsal groove of the pharynx and is passed on into the intestine. The living animal after being fed in this manner has the appearance indicated in Fig. 1.

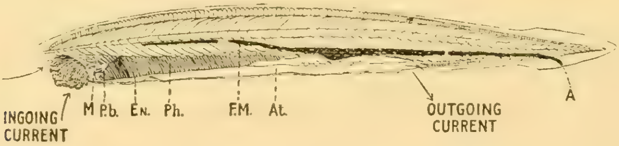

Fig. 1.[†]—View of a living Amphioxus shortly after being fed with carmine particles, to show the collection of food in the dorsal groove and the intestine, and the course of the main current through the body (× about $\frac{5}{3}$).

F.M.	Food masses in the dorsal groove of the pharynx and in the intestine.
M.	Mouth, between which and the end of the arrow indicating the ingoing current is situated the buccal cavity. The outgoing current leaves the animal at the atriopore.
At.	The Atrium, the space between the pharynx and the body wall through which the current passes after leaving the pharynx, Ph.
Ph.	The pharynx or branchial sac.
En.	The endostyle.
P.b.	The peri-pharyngeal band of the left side.
A.	Anus.

[*] The observations recorded in this paper were made on the species *Branchiostoma lanceolatum*. The general similarity in structure of the species of this genus, however, renders it highly probable that the processes here described will apply to all the group.

[†] I am indebted to Mrs. Orton for the drawing for this figure, and also for assistance with Figures 6, 8, and 9.

If the animal is examined closely by means of a microscope when feeding it is easy to make out a strong current entering at the anterior end of the animal between the buccal tentacles. Thence the current can be followed successively through the buccal cavity, the mouth, the pharynx,

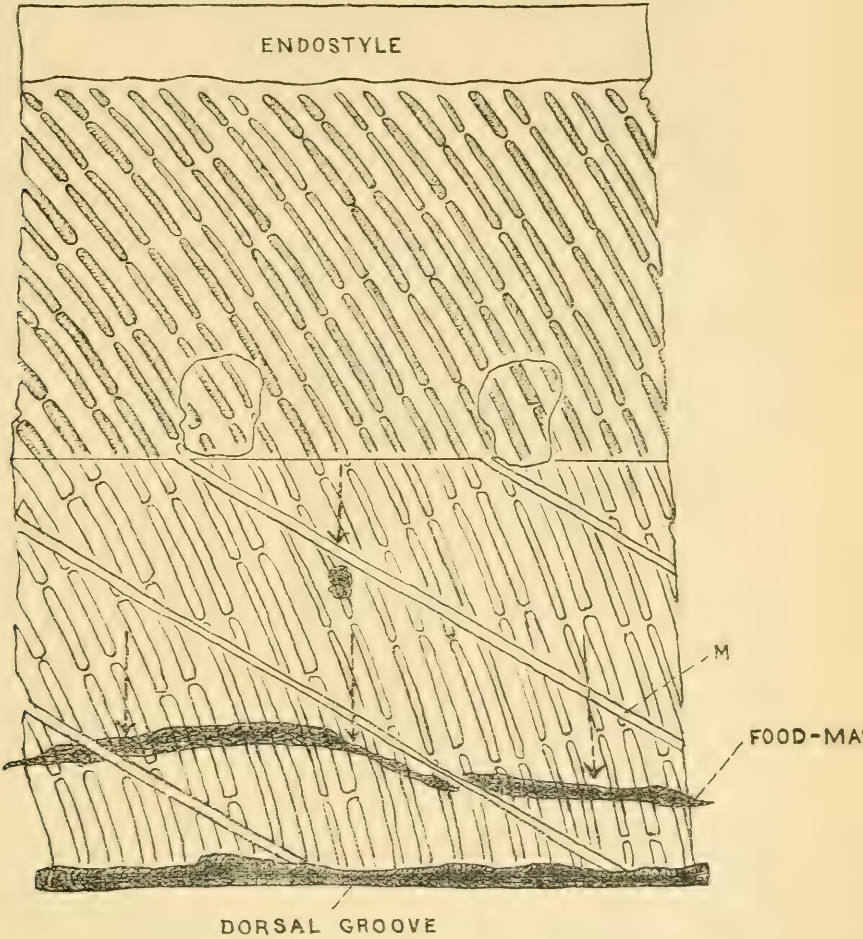

FIG. 2.—View of a portion of the body wall and pharynx of a living entire Amphioxus at about the level of the posterior two-thirds of the pharynx.* (Drawn as seen through a microscope, × about 37.)

D.Gr.	Dorsal groove in which becomes collected a mass of food particles embedded in mucus.
F.M.	Cylindrical mass of mucus with embedded food-particles being transported away from the endostyle towards the dorsal groove, as is indicated by the overlying vertical arrows.
M.	The boundary of adjacent myotomes.

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* It was found the most convenient for this examination to view the animal laid on its right side. Thus in this view the main current passes from the reader's right to the left

and the atrium ; it is finally seen to pass out of the animal at the atriopore. If now the pharynx of the living animal be examined carefully while feeding is going on the process of collection of the food-particles may be watched. As particles pass along the pharynx they may be seen to be drawn up against the internal wall of this organ. Instead, however, of becoming collected in the endostyle as has been generally stated to be the case, the particles become caught in thin sheets of mucus and travel *dorsally* on the internal wall of the pharynx towards the dorsal groove, into which they disappear. If the animal is taking in a large number of food-particles, these often become worked up with mucus into a long cylindrical mass which travels as a whole away from the endostyle towards the dorsal groove, as is shown in Fig. 2. This figure is a drawing of a view of the pharynx of a living animal seen through the transparent body wall, the food-particles being visible through the gill-bars. Food-particles massed together in various shapes may also be seen—like that depicted in the middle of this figure just above the food-mass—all travelling towards the dorsal groove, which in this way becomes very quickly charged with the collected food.

CILIARY MECHANISMS ON THE GILL OF AMPHIOXUS.

It is thus obvious that there exists some mechanism for collecting and transporting food-particles along the internal face of the gill-bars. If a portion of the living gill, such as that shown in Fig. 3, be now observed in a little water in a watch-glass under the microscope, this mechanism can be examined. The mechanism, however, is more easily made out if a little finely powdered carmine be added to the water. Very soon after the carmine grains are added they may be seen to be drawn towards the internal face of the gill-bars, along which they are hurried in a direction away from the endostyle, and may become collected into a cylindrical mass such as is shown on the right side in Fig. 3. The arrows on this side of the figure indicate the direction in which the particles and the collected mass travel. Individual particles may be seen to travel at an angle across the bars, i.e. in a ventro-dorsal direction, as is indicated also by the arrows. The mechanism which causes the movement of these particles across the gill-bars cannot be made out easily when examining the gill from this point of view, but when a single gill-bar is examined in side view, highly magnified (see Fig. 4), it is seen that on the internal face of the bar there is a row of relatively short cilia (Fig. 4, fc.) which lash rapidly along the length of the bar and thus effect the translation of such particles as are drawn against it. That the particles are drawn against the bars is very easily seen even in a view like that of Fig. 3, and if the lateral, i.e. the anterior and posterior, faces of the gill-bars be focussed carefully, rows of long, rapidly moving cilia are to be seen lashing across the length of the bars. In Fig. 4 this direction is indicated by the large arrows. In a view of a portion of the pharynx, as shown in Fig. 3, these lateral cilia—as they may be called—lash in the direction shown by the arrows on the reader's left-hand side, and thus draw water with suspended particles against the side of the gill. Water is actually lashed between the gill-bars, as is indicated by the lower arrow on the extreme left of this figure, while the suspended particles are caught in mucus on the face of the gill-bars, and, as we have already seen, are carried away from the endostyle towards the dorsal groove (see Fig. 3 again on the right). In the

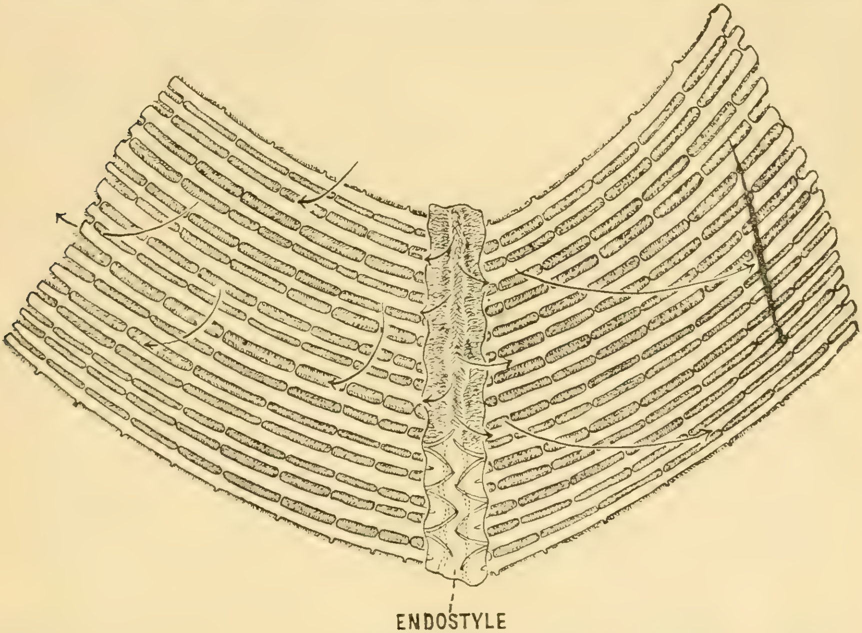

FIG. 3.—View of a portion of the pharynx of Amphioxus to show the cilia producing the main current (on the left) and the collection and transportation of food-particles (on the right). The portion consists of a piece of the endostyle with gill-bars attached. (Drawn from the living object, × ca. 32.)

The arrows on the reader's left indicate the direction in which the main current is drawn by the lateral cilia on the gill-bars. These cilia are shown bordering the gill-slits. The arrows on the reader's right show the direction in which the frontal or pharyngeal cilia on the gill-bars are transporting a mass of food-particles away from the endostyle towards the dorsal groove. The upper arrow on the right-hand side of the figure points to the food-mass. The small arrows in the middle of the figure on the endostyle show the direction in which the outer, i.e. lateral cilia, on the endostyle transport particles out of the endostylar groove on to the gill-bars. The supporting rods of only a few of the gill-bars are shown.

lateral view of a gill-bar or a gill-filament, shown in Fig. 4, scattered cilia can be seen on the atrial epithelium. These cilia appear to lash in the direction shown by the arrow on the atrial side of the bar, and by comparison with a gill-filament of a Lamellibranch, may be called ab-frontal cilia. They probably help in a small way in producing the main current and also in cleaning the atrial surface of the gill-bar.

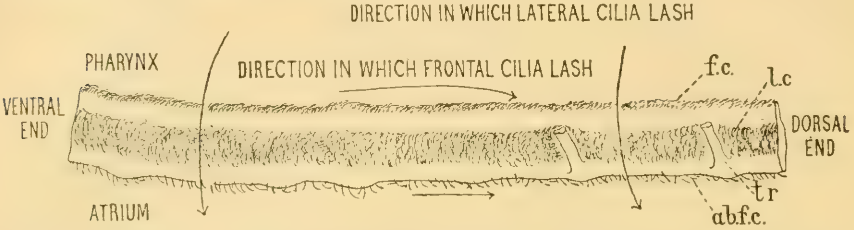
DIRECTION IN WHICH LATERAL CILIA LASH
PHARYNX
DIRECTION IN WHICH FRONTAL CILIA LASH
f.c.
l.c
VENTRAL END
DORSAL END
ATRIUM
tr
ab.f.c.

FIG. 4.*—Side view of a single living primary gill-bar of Amphioxus, showing the ciliary mechanisms.

The direction in which the lateral cilia, l.c., lash, to produce the main current is shown by the large arrows crossing the gill-bar.

The direction in which the frontal cilia, f.c., lash is indicated by the arrow above these cilia. The true direction in which these particles transport cilia is along the face of the gill-bar and upwards towards the reader.

The ab-frontal cilia, ab.f.c., appear also to lash in a similar direction to that of the frontal cilia as is shown by the accompanying arrow.

l.c.	Lateral row of cilia.
f.c.†	Frontal or pharyngeal row of cilia.
ab.f.c.	Scattered cilia on the atrial or ab-frontal face of the gill-bar.
Ph.	Pharyngeal side of gill-bar.
Atr.	Atrial or peri-branchial side of gill-bar.
V.	Ventral end of gill-bar.
tr.	Connexions joining the gill-bar to others.

CILIATION OF THE ENDOSTYLE.

There still remains for examination the ciliation on the endostyle. Under a low power in such a view as Fig. 3, particles suspended in the water may be observed to be lashed rapidly out of the endostyle on to the face of the gill-bars in the direction denoted by the small arrows in the middle of the figure (i.e. on the endostyle). Examination of the endostyle under a high power brings out the presence of three main sets of cilia, two outer or lateral sets and one median. The cilia on these lateral rows are short and lash rapidly across the length of the endostyle. These are the cilia which throw particles out of the endostyle on to the gill-bars. The median cilia on the endostyle are long and appear only to shake with a wave-like motion which begins at the attached end. Particles may indeed be observed to rest on these cilia for some time, but such particles are eventually worked towards the lateral sets of cilia, which soon transport them to the gill-bars. In the passage of the particles from the median to the lateral cilia on the endostyle one can often make out that the particles have become embedded in mucus. It is therefore doubtless the function of the median cilia on the endostyle to pass on mucus secreted by the endostyle to the lateral endostyle cilia and thence to the gill-bars. This mucus, along with that doubtless secreted also by the pharyngeal epithelium of the gill-bars, serves to entrap food-particles and render the transportation of these easier.

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* I am indebted to Mr. L. R. Crawshay for the lettering in this figure, and also for that in Figures 2, 3, and 5.

† The short cilia figured by Benham (15, Plate 6) have not yet been seen in the living filament, although they have been carefully looked for. Further observations, however, will be made on this point.

Between the median and lateral sets of cilia on the endostyle a narrow ciliated groove can be made out on either side (see Fig. 3). Particles are frequently caught in these grooves, but they can be seen to be passed quickly on to the lateral endostyle cilia and generally on to those portions of the endostyle overlying a primary bar, and thence to the gill-bars.

Before passing on to a recapitulation of the ciliary mechanisms and their function in Amphioxus, it will be convenient to examine the ciliary arrangements so well known in the anterior end of the animal, namely those in the buccal cavity, the wheel organ, and Hatchek's pit, and the peri-pharyngeal bands.

THE FUNCTION OF THE WHEEL ORGAN, AND THE PERI-PHARYNGEAL BANDS IN AMPHIOXUS.*

The action of these organs can be made out by examining the anterior end of the living animal through a microscope while it is feeding. During the act of feeding the buccal tentacles are kept folded over one another. In this way these tentacles act as a sieve, allowing only the finer suspended particles to pass on into the buccal cavity. The efficiency of the buccal tentacles in straining, when held in this manner, is increased by the presence along the sides of the tentacles of conical papillæ which subdivide the spaces between the tentacles, as is shown in Fig. 5. In this manner the larger particles carried along in the ingoing current become arrested on the buccal tentacles, only the finer particles being allowed to pass onwards. A selection of the finer food-particles is thus effected.

From the buccal tentacles the main current with the suspended particles passes through the buccal cavity, the mouth and onwards into the pharynx.

In the buccal cavity, however, some particles fall out of the main stream as a result of the occurrence of slack waters in the periphery of this region, and become drawn against the wall of this cavity by the sets of cilia which are known collectively as the wheel organ. These sets of cilia are shown on the wall of the buccal cavity in Fig. 5. They are really ciliated grooves running antero-posteriorly in the posterior part of the buccal cavity. Around the mouth these paths are connected together by a circular ciliated path, which is stated by V. Wijhe (4) to be sometimes complete and sometimes incomplete. These ciliated paths have been said to be " an organ for creating currents in the mouth back to the pharynx." There can be little doubt about their function, however, if they are watched while the animal is feeding. As particles drop out of the main current in the buccal cavity they very quickly become caught in the anterior end of one or other of these ciliated paths and rapidly whirled along the groove towards the mouth, becoming rolled into a

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* See Appendix on page 45 for an account of Andrew's work on feeding in Amphioxus.

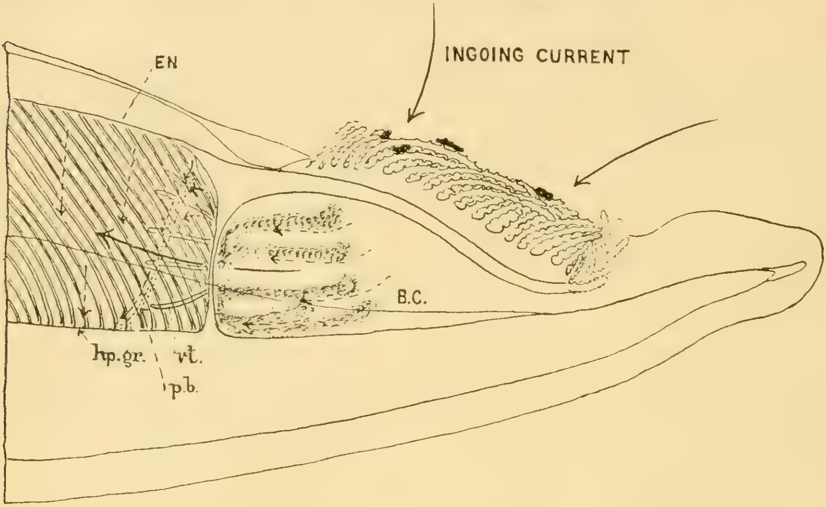

Fig. 5.—View of the anterior end of a living Amphioxus (drawn as seen through a microscope, × ca. 27), after keeping the animal in a dilute solution of methylene blue in water. This view shows the action of the buccal tentacles in sieving off the coarser food-particles at the entrance to the buccal cavity, the action of the ciliated grooves (the Wheel Organ) in the wall of the buccal cavity, and the collection of food-particles from this region of the body into the peri-pharyngeal bands.

b.c.	Buccal cavity.
hp. gr.	Dorsal or hyperpharyngeal groove.
p.b.	Peri-pharyngeal band.
v.t.	Velar tentacles.
EN.	Region of the endostyle.

The arrows in the buccal cavity lie alongside the ciliated grooves, along which food-particles are lashed towards the mouth in the direction indicated by the arrows. The large arrow passing through the mouth from the buccal cavity into the pharynx indicates the course of the main stream.

mass with mucus on the way. A large number of these minor food-masses, however, are swept into the main stream as they approach the oral aperture and pass onwards into the pharynx. Some particles, however, appear to pass between and sometimes along the velar tentacles on to the internal surface of the pharynx, whence they are passed on to the peri-pharyngeal grooves. It is well known that there are no gill openings anterior to the peri-pharyngeal grooves. Thus the part of the pharynx anterior to the peri-pharyngeal grooves serves as a collecting ground for the food-particles which have been caught in the buccal cavity. Most of the particles, however, appear to pass around the ventral part of the mouth to the peri-pharyngeal groove; while others appear to pass dorsally straight into the dorsal groove. There is also, however, a steady dribble of particles into the peri-pharyngeal groove from a position immediately ventral to it. These particles are probably collected from the extreme anterior portion of the endostyle, by which they are ejected in the same way as we have seen at other parts. Doubtless these minor streams have been the cause of the erroneous views which are current on the mode of feeding in Amphioxus. If a little methylene blue is added to the water from which an Amphioxus is feeding the edges of the ciliated paths in the buccal cavity stain blue, which doubtless indicates the presence of mucus glands at these points (see Fig. 5). The anterior end of each ciliated groove can now be easily seen to form a pit-like depression around which the cilia are lashing vigorously. As particles are caught by the cilia they are seen to be passed along in the middle of the groove towards the mouth, as has been described above.*

RECAPITULATION OF THE ACCOUNT OF THE FOOD AND RESPIRATORY CURRENTS IN AMPHIOXUS.

The main food and respiratory current in Amphioxus is produced by the lashing of the lateral rows of cilia on the gill-bars or gill-filaments (see Fig. 4, l.c., Fig. 3, and Fig. 6). These lateral cilia lash across the length of the filament from the cavity of the pharynx to that of the atrium. In the adult Amphioxus there are about 180 gill-filaments on each side of the body (Willey, 1. p. 17). Each of these carries two long rows of lateral cilia, hence in all there are about 720 rows of long cilia acting like oars lashing water through the body of the animal. These are indeed powerful enough to produce the strong current that is to be observed.

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* If a stronger solution of methylene blue is used the whole of the wheel organ as well as the pharynx stains a deep blue, and a surprising amount of detail can be made out over the whole of the body.

The main cilia which collect and transport the food-particles are those on the pharyngeal surface of the gill-filaments, namely, the frontal cilia (see Figs. 4 and 6, f.c., and Fig. 3). These cilia lash in a direction which is chiefly along the length of the bars, but actually at an angle to the bars in a ventro-dorsal direction (see the arrows on the right side of Fig. 3). The gill-bars, it is to be remembered, run in the living animal in an antero-dorsal to postero-ventral course, as is shown in Figs. 1, 2, and 3. Food-collection is effected in the following manner. Mucus is secreted by the endostyle and passed on to the gill-bars in a thin sheet by the cilia on the lateral portions of the endostyle. Probably mucus is secreted also by the pharyngeal epithelium of the gill-bars. Food-particles are drawn against the gill-filaments by the lateral cilia on those filaments, as we have already seen; the particles become entangled in the mucus in which they are hurried along the face of the gill-bars into the dorsal groove by the frontal or pharyngeal cilia. The actions of these different mechanisms are depicted in the accompanying diagram, Fig. 6.

It is thus evident that feeding in Amphioxus occurs automatically as in the Lamellibranchs. Amphioxus, however, has an advantage over most Lamellibranchs in being able to swim away from a region where the water is laden with innutritious or undesirable particles. And, indeed, the occurrence of Amphioxus mainly on shelly or gravelly grounds may be due largely to the desire of the animal to seek out grounds where the water is relatively free from undesirable, i.e. innutritious particles.

A food-collection of minor importance is also effected, as we have seen, in the buccal cavity. Food-particles are collected into the ciliated grooves on the wall of this cavity and transported in mucus through the mouth to the peri-pharyngeal bands, often, however, these particles are drawn into the pharynx in the main stream at the oral aperture.

These ciliated grooves in the buccal cavity doubtless lend some small aid to the lateral cilia of the gill-filaments in producing the main current, as probably also do the ab-frontal cilia of the filaments. Short cilia have also been observed on the atrial epithelium overlying the gonads. These cilia lash ventrally, and thus help somewhat in producing the main current.

THE FUNCTION OF THE PHARYNX IN AMPHIOXUS.

It is generally stated that the gill of Amphioxus functions mainly as a respiratory and only secondarily as a feeding organ. In the light of the present researches, however, it would appear that the pharynx functions

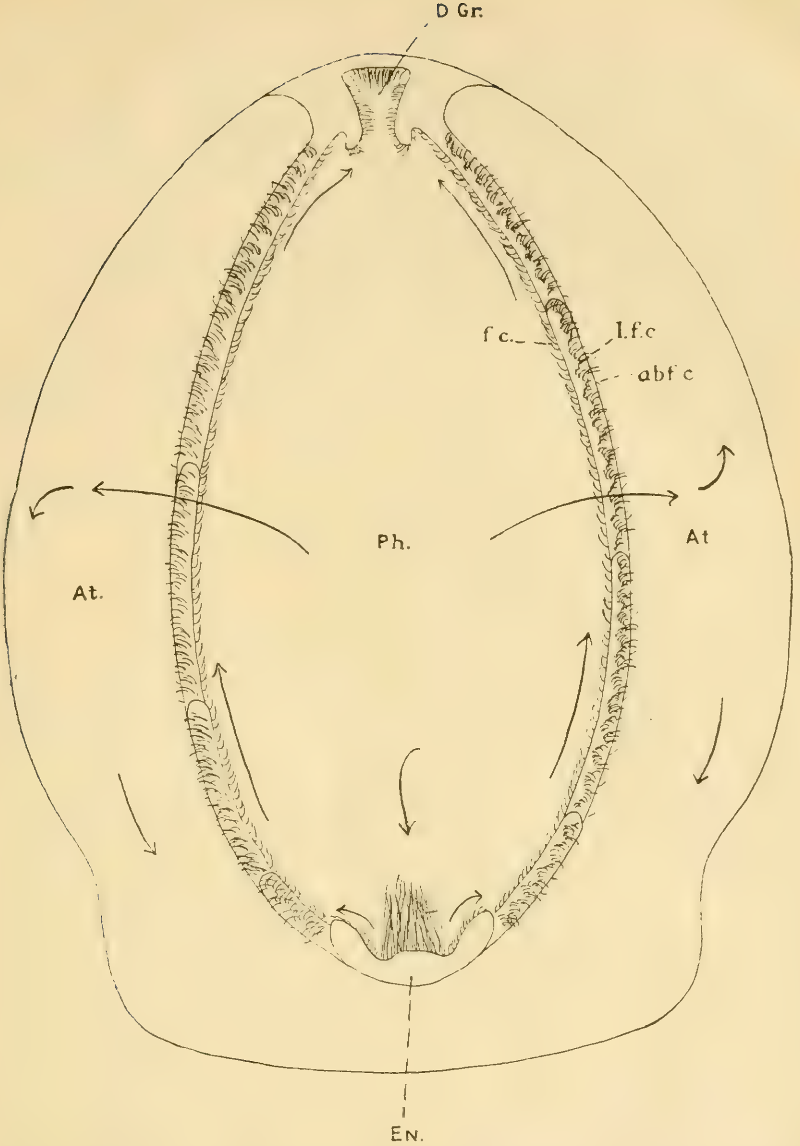

Fig. 6.—Diagram of a transverse section of the pharynx and atrium of Amphioxus to show the ciliary mechanisms on the gill, which produce the main current and collect and transport food-particles. (This diagram serves equally well also for Ascidians.)

Ph. Pharynx, in the walls of which are shown several gill-bars.

At. Atrium.

En. Endostyle, the lateral cilia of which pass on mucus and food-particles from the median cilia to the gill-bars.

D.Gr. Dorsal groove of pharynx.

l.f.c. Lateral cilia on the gill-bars. These produce the main current which passes across the gill from the pharynx to the atrium in the direction indicated by the large arrows which cross the gill-bars about the middle of the figure. (These cilia should have been denoted in the figure by the letters l.c.)

f.c. Frontal or pharyngeal cilia. These cilia are the chief collectors and transporters of food-particles, which become caught in the mucus passed on to the gill from the endostyle. The captured food-particles are transported towards and into the dorsal groove, as indicated by the arrows along the inside of the gill-bars.

mainly as a water pump and a feeding organ, and it may indeed be doubted whether on the whole oxygenation of the blood occurs in the gill at all. On the other hand, the expenditure of such a large amount of energy as is necessary to produce the main and food currents may well leave the blood as it issues from the gill in a less pure condition than that in which it entered. Moreover, it is to be remembered that the gill-filaments of Amphioxus are very compact organs in which only the coelomic blood-vessel lies at all near the surface (see Benham, 15, Pl. 6).

It would therefore seem more probable that oxygenation of the blood in Amphioxus takes place in the relatively vast coelomic spaces adjacent to the atrium, as, for instance, the endostylar coelomic canal in which is contained the branchial artery, and the various coelomic spaces in the dorsal regions of the atrium. Thus it is highly probable that the gill of Amphioxus, like that of Lamellibranchs (see later, pp. 44 and 45), is mainly a feeding organ and a water pump.

THE MODE OF FEEDING IN ASCIDIANS.

The similarity in general structure in the gills of Amphioxus and Ascidians renders the mode of feeding in the Ascidians a matter of much interest in comparison with that of Amphioxus.

The mode of food-collection in Ascidians has been investigated by many zoologists, and correctly described by Fol (17) in various Ascidians, and later by Roule (8, pp. 66, 67) in Ciona. It is curious that English writers, including Willey (1, p. 185) and Herdman (9, pp. 15 and 16, p. 46), describe the process differently, apparently accepting the earlier work of Fol (4, 1872). Fol, in a summary of his later work (17, p. 240), states that "Die Rinne (the endostyle) ist kein Ernährungs-abschnitt des Kiemenkorbes sondern ein Drüsenorgan. Die Nahrungsaufnahme findet gleichzeitig mit der Athmung im ganzen Kiemenkorbe statt." Roule describing this process in Ciona states: "Un mucus, sécrété par le raphé ventral, est déversé en fins filaments sur la face interne de la paroi branchiale ; là, ces filaments agglutinent tous les petits corpuscules, amenés par l'eau, qui passent à leur portée ; puis, entraînés par les mouvements des cils vibratiles des papilles, ils se dirigent obliquement en haut et en arrière, de telle sorte que les filaments les plus antérieurs se rassemblent en une seule masse qui suit le raphé dorsal pour pénétrer dans la bouche œsophagienne, tandis que les postérieurs y parviennent directement." On the other hand, English writers describe food-collection as occurring in the endostyle and peri-pharyngeal grooves; the former groove conducting mucus with contained particles forwards to the latter, which in turn carries the food-mass upwards into the dorsal groove, and at the same time assists in capturing food-particles. Delage and Herouard (3, p. 144) point out the differences in the descriptions of this process, and cautiously give only a general account.

FOOD-COLLECTION IN VARIOUS ASCIDIANS.

Observations have been made on a number of Ascidians, namely, *Ascidiella aspersa*, *Phallusia mamillata*, *Ascidia mentula* and *virginea*, *Ciona intestinalis*, *Clavellina lepadiformis*, *Leptoclinum* (*Diplosoma*) *gelatinosum* and a species of *Morchellium*, with the result that the process of food-collection has been found to be the same in all these animals as that described by Fol and Roule.

When carmine particles are added to the water in which one of these animals is living, for example, *Ascidia mentula*, the particles may be observed with a hand lens to be drawn into the branchial cavity and against the wall of the gill. Particles approaching the endostyle, however, are seen to be immediately lashed out of this groove on to the wall of the pharynx, just as is the case in Amphioxus. These particles become rolled into a mass with mucus, and are transported *across* the branchial sac to the dorsal lamina. All the particles entering the endostyle are washed out on to the pharynx in this way, and no mass of collected food has ever been seen—in any of the animals examined—to be passed forwards along the endostyle. An examination of the endostyle through a microscope shows further that the lateral rows of cilia on this organ lash in a direction across the endostyle, and from the endostyle on to the pharynx, and no transference of food-particles along the endostyle is seen. The food-particles drawn against the pharynx become caught in mucus and gradually transferred across the wall of the pharynx to the dorsal lamina, becoming rolled into cylindrical masses with mucus on the way. This process of food-collection and transportation is very well seen in the Compound Ascidian *Leptoclinum* (*Diplosoma*) *gelatinosum*, as shown in Fig. 7, which is a drawing of one living zooid in the act of feeding. In such a small animal as this one is able to keep the whole animal in the field of a microscope, and so to follow the course of even small food-particles in the pharynx. The particles entering the branchial cavity sometimes fall on to the pharyngeal wall close to the peri-pharyngeal grooves, but in none of the animals examined have the particles posterior to the grooves been observed to be drawn into these grooves. On the contrary, in *Ascidiella aspersa* especially these food-particles become collected in masses some distance posterior to the peri-pharyngeal groove as though the cilia in this region were lashing away from the groove. The particles falling on to the region between the buccal tentacles and the peri-pharyngeal grooves, however, are washed into these grooves by cilia in a manner somewhat similar to that observed in Amphioxus.

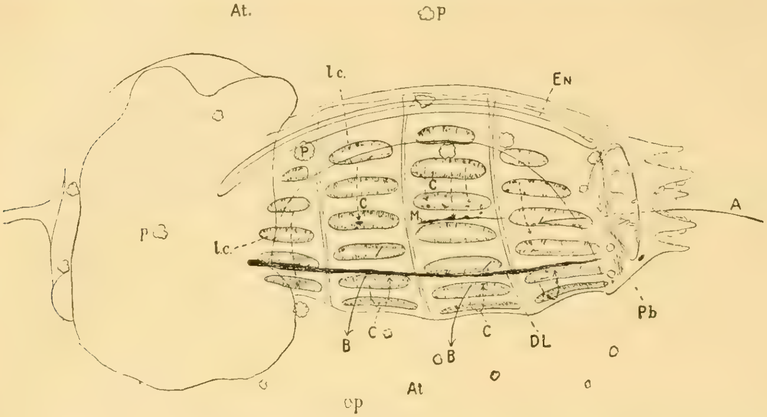

Fig. 7.—View of one entire zooid of the compound Ascidian, *Leptoclinum gelatinosum*, to show the currents produced by the ciliary mechanism on the gill and the mode of food-collection.

(Drawn from the living animal seen through the microscope, × about 60.) The large arrows indicate the direction of the main current, and the dotted ones the course of food-particles which have been captured and are being transported to the dorsal lamina. Only the gill slits on the upper surface are shown.

A.	Arrow indicating the direction of the inhalent current produced by the lateral cilia, l.c.
l.c.	Lateral cilia on the sides of the gill slits: these produce the main current by lashing from the pharynx towards the atrium.
B.	Arrows indicating the current passing through the gill slits into the atrium.
C.	Dotted arrows indicating the paths of the food-particles, as at M, captured in mucus and travelling away from the endostyle towards the dorsal lamina, DL.
DL.	Dorsal lamina filled with collected food-particles seen through the wall of the transparent pharynx.
En.	Endostyle.
M.	Food-particles embedded in mucus being transported by the frontal cilia on the gill towards the dorsal lamina.
P.	Pigment spots scattered about the surface of the colony.
At.	Common atrium of the colony.
P.b.	Peri-pharyngeal band.

When Leptoclinum (Diplosoma) is fed with a large amount of carmine particles the process of feeding occurs extremely rapidly. Within a few seconds from adding particles to the water the dorsal lamina becomes full of the particles embedded in mucus ready to be passed into the œsophagus. Clavellina can be observed through the microscope to feed in the same way, and almost as rapidly as Leptoclinum. Ascidiella and Ciona feed more quickly than the other simple forms, which feed relatively slowly. The process of food-collection at the anterior end of the pharynx in *Ascidia mentula* is shown in Fig. 8. At the posterior end of the pharynx in this animal the cilia in the dorsal groove lash food-particles *forwards* to the œsophageal opening. This process can be easily observed by cutting from the test a window, through which the processes can be followed distinctly.

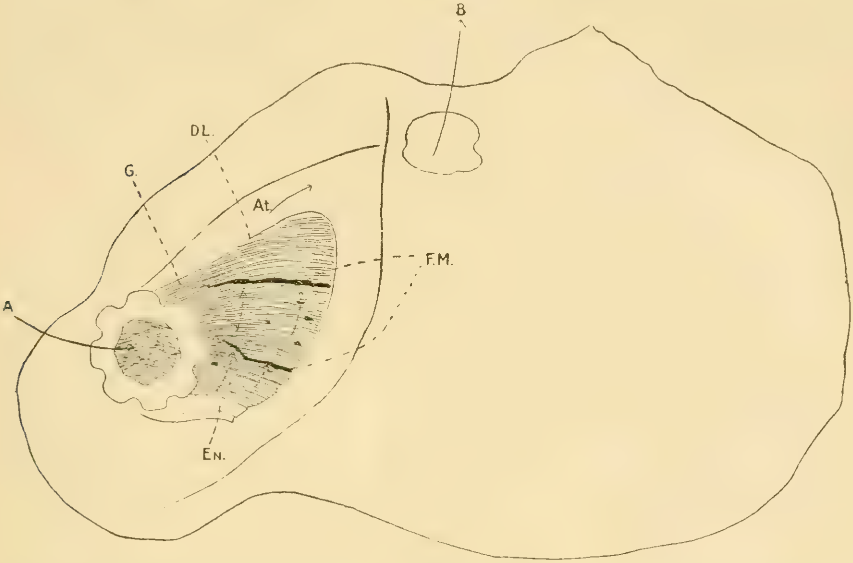

Fig. 8.—A view of the anterior end of *Ascidia mentula* to show the mode of feeding. Drawn from the living animal, as seen through a hand-lens. A part of the pharynx is drawn as though the test were transparent. (× ca. $\frac{4}{5}$.)

A.	Arrow indicating the direction of the inhalent current.
B.	Arrow indicating the direction of the exhalent current.
At.	Arrow in the atrium showing the direction of the main current after passing through the gill slits.
En.	Endostyle.
D.L.	Locus of the dorsal lamina.
F.M.	Food-particles collected into a cylindrical mass with mucus being transported across the gill-bars and away from the endostyle towards the dorsal lamina, as indicated by the dotted arrows alongside.
G.	One of the longitudinal bars of the gill.

CILIARY MECHANISMS ON THE GILL OF ASCIDIANS.

The main current through the branchial cavity of all the Ascidians examined is produced by the lashings of the cilia on the sides of the gill-bars, as has been observed by Herdman for *Ascidia mentula* (10, p. 47). Food-collection is effected by the cilia on the pharyngeal surface of the gill-bars and the cilia on the papillæ on the bars. These cilia lash across the length of the pharynx from the endostyle towards the dorsal lamina, but are not specially active nor specially powerful in the simple Ascidians, and food-collection is accelerated by the waving of the longitudinal bars in a transverse direction. In this way the food masses are pushed on as well as lashed onwards towards the dorsal groove. The papillæ of the gill-bars thus assist in food-collection, and in those animals in which they point towards the dorsal lamina, as in *Ascidia mentula*, act somewhat like the bristles of a brush in pushing food masses onwards. In *Ascidia mentula* cilia have been observed on the atrial surface of the gill-bars and the atrial epithelium of the peri-branchial wall; doubtless these are present also in other Ascidians, and have the function of cleaning the walls of the atrium.

The cilia on the outer or lateral portions of the endostyle lash from the endostyle groove on to the pharynx, and in this way doubtless function mainly in transferring mucus secreted by the endostyle on to the walls of the pharynx. These cilia, moreover, are probably seldom required to throw particles on to the gill, for the tendency of the main stream will be to pass towards the middle of the pharynx where the main pull on the water is being effected by the lateral cilia. Herdman (9, p. 17) has estimated the number of gill openings in an adult *Ascidia mentula* of medium size to be about 192,000, and as there are rows of lateral cilia on each side of these slits, there are in all about 384,000 short rows of cilia lashing water through the pharynx of the animal; the main direction of the current thus produced (see Figs. 7 and 8) is away from the endostyle. It is therefore curious that this groove can ever have been regarded as an important food-collecting organ. On the outer edge of the endostyle of Ciona there are definite short transverse grooves in which the cilia are specially powerful, and lash from the endostylar groove on to the pharynx.

The median ciliated tract of the endostyle bears cilia up to two millimetres in length. Roule (8) describes the cilia as having a very slow movement directed along the length of the groove and consisting of a series of undulations beginning at the base of the cilia. I have not yet been able to detect any movement in these cilia, and am therefore in some little doubt as to their function. Since, however, food-particles are not transported in the endostylar groove, these cilia do not appear to have any transporting function. This view is further supported by the fact that transporting cilia in Gastropods, Lamellibranchs (see 5, *passim*), and Amphioxus are always relatively very short and vibrate rapidly. Perhaps the function of these cilia may be detected by examining their action through a microscope in the whole living and feeding animal, and an attempt will be made to find an animal in which this is possible. It is probable that they assist in passing mucus on to the walls of the pharynx, as has been suggested for the similar cilia in Amphioxus.

Examination of the peri-pharyngeal bands through a microscope shows that the cilia in these grooves lash from the endostyle towards the dorsal lamina. These grooves serve to collect and transport to the dorsal lamina such particles as fall out of the main stream at the entrance to the pharynx.

COMPARISON OF THE MODE OF FEEDING IN AMPHIOXUS AND ASCIDIANS.

From the foregoing description it will be seen that there is an exact correspondence in the mode of feeding in Amphioxus and Ascidians. In these animals the lateral cilia on the gill-bars are the main factors in producing the main current ; mucus is passed on to the gill-bars by the outer tracts of cilia on the endostyle, and food-particles are collected and transported to the dorsal region of the gill by the pharyngeal or frontal cilia on the gill-bars. The food collected in the dorsal wall of the pharynx is transported backwards, to be passed into the digestive tract. Thus the diagram of the ciliary mechanism on the gill of Amphioxus (see Fig. 6) will serve equally well for Ascidians in general. The cilia in the peri-pharyngeal bands in both of these groups of animals lash from the endostyle towards the dorsal groove, and collect and transport to the dorsal groove those particles which fall out of the main stream at the entrance to the pharynx. The process of feeding in both Amphioxus and Ascidians is automatic, but at the same time these animals are able to select from the food-stream the finer food-particles by means of their buccal tentacles. Ascidians, moreover, have been observed to reject food after it has been collected in masses on the gill by suddenly contracting the walls of the pharynx and expelling the whole mass. It is also not improbable that the pharyngocloacal slits observed by Garstang in Ascidians (18, p. 132), may be exits from the pharynx used for relieving that organ when overburdened with undesirable matter. On the other hand Amphioxus is obliged to ingest all that passes beyond the oral aperture.

THE FUNCTION OF THE GLAND AND ITS CILIATED TRACT IN THE BRANCHIAL OPENINGS OF AMPHIOXUS AND ASCIDIANS.

In the anterior region of these animals there are also similar organs which have doubtless a similar function, and a function in connexion with the mode of feeding. These organs are a gland, and a ciliated tract connecting the gland with the pharynx, namely, the sensory pit or Hatchek's pit, and the Wheel Organ in Amphioxus, and the neural gland and the dorsal tubercle in Ascidians. It has been suggested by V. Wijhe (7, p. 121) and Andrews (14, p. 227) for Amphioxus, and by Herdman (10, p. 52), Hartmeyer (11, p. 303), and Seeliger and Neumann (12, p. 61) for Ascidians, that this gland may have the function of secreting mucus which is passed on to the pharynx by the ciliated tract. The observations here made on these groups of animals support these views. The gland probably merely secretes mucus which is passed on to the food-grooves by the ciliated tract to serve for entrapping or embedding food-particles and rendering the transportation of these easier than it otherwise would be. Thus it is not improbable that the great variations observed in the openings of the dorsal tubercle of Ascidians may be a means of distributing mucus in various ways to the pharynx in correlation with minor differences of food-collection on the pharynx ; such differences as may be due to the well-known differences in structure of the pharynx.

From the occurrence of sensory cells in Hatchek's pit in Amphioxus it would seem that this organ is also in some way sensory, as V. Wijhe (7, p. 120) has pointed out. In the light of the present researches it is suggested that possibly this sensory pit may govern in some way the supply of mucus from the gland itself and the endostyle, for the capture of food-particles depends to a great extent on the amount of mucus passing over the pharynx. Thus when a large amount of food-particles is passing into the pharynx—as might be first appreciated by the sensory cells in Hatchek's pit—a large amount of mucus would be required to capture the food-particles. It is therefore not improbable that the supply of mucus may be regulated by means of this sensory pit. Whether any similar function is exercised by the neural gland in Ascidians is perhaps more doubtful, but both Herdman (10, p. 52–3) and Seeliger and Hartmeyer (11, p. 303) suggest that the dorsal tubercle in these animals may have a sensory function. It may also be pointed out here that if the neural gland in Ascidians is an organ for secreting mucus which is passed on to the pharynx by the cilia in the dorsal tubercle, then this mucus must be passed straight into the dorsal groove. The cilia on the dorsal tubercle of Ciona when examined under a microscope appear to lash away from the body-wall towards the lumen of the branchial opening. Thus in the whole animal it is not improbable that thin sheets of mucus are constantly passing from the dorsal tubercle into the dorsal groove. These sheets would serve to entrap food-particles in the same way as the ciliated tracts do in Amphioxus. It is hoped, however, to complete these observations on a suitable animal and to obtain more definite information on this subject.

THE MAINTENANCE OF THE PHARYNGEAL SPACES IN ASCIDIANS AND AMPHIOXUS.

The maintenance of a current of water through the body of these animals is dependent upon the maintenance of a continuous open passage through the animal as well as upon the action of the gill as a water pump. In Ascidians doubtless the main function of the test is to maintain a cavity for the branchial sac. The body wall in Ascidians is maintained in close contact with the test by organic connexions, so that the branchial sac lies free in a cavity—the peri-branchial cavity—which the expanded pharynx does not quite fill. Thus a cavity in communication with the pharynx and the exterior is maintained outside the pharynx. The pharynx in Ascidians is kept open by the intercrossing of longitudinal and transverse bars of a sufficiently rigid consistency. In Amphioxus the pharyngeal bars are supported, as is well known, by definite skeletal rods. The peri-branchial cavity in Amphioxus, however, is maintained by dorso-lateral sheaths of connective tissue arising from the notochordal sheath (see Lankester, 16, Plate 36) held in position above the pharynx and connected to the lateral surface of the notochord and dorsal skeletal system by the myotomes. A glance at a pharyngeal section of this animal indicates at once how the attachment of the myotomes to the dorsal region of the body and the dorso-lateral sheaths in the wall of the peri-branchial cavity maintains this cavity. Indeed, the shape of the myotomes in Amphioxus may have been directly influenced by their function of assisting in maintaining a cavity in the ventral region of the body.

THE CILIATION OF THE GILL OF BALANOGLOSSUS.

Up to the present it has been possible to examine only sections of the gill of this animal, but it is hoped that observations may be made on the living animal later. Examination of sections of the gill-bars of Balanoglossus (a species of Ptychodera) shows the presence of well-marked lateral cilia and smaller frontal or pharyngeal cilia. From the foregoing observations it is a fair deduction that these lateral cilia produce the main current of water through the body of the animal, and that the frontal cilia are concerned in some way in food-collection. It is also highly probable that observations on this group of animals may now demonstrate the function of the mucus, which is doubtless secreted by the dorsal diverticulum, the gland in this group of animals corresponding to Hatchek's pit in Amphioxus and the neural gland in Ascidians.

OBSERVATIONS ON THE AMMOCOETE OF *PETROMYZON FLUVIATILIS.*

Some observations have also been made on rather late stages of the Ammocoete of *Petromyzon fluviatilis*. It is well known that this larva closely resembles Amphioxus in some respects. I have also learnt from fishermen that these larvæ will live in captivity for even a year by merely changing regularly the water in which they are kept. It was therefore thought probable that they might feed on Plankton in the same way as Amphioxus. Two specimens were fed on carmine particles and then preserved in 90% alcohol. On opening the branchial portion of the alimentary canal it was found that the carmine particles had become entrapped in mucus and were collected along the gill-bars and roof of the pharynx. No particles, however, were found in the intestine. Nevertheless sufficient evidence was obtained to indicate that further observations on the mode of feeding in younger forms might be highly interesting, and an effort will be made to make such observations.

THE MODE OF FEEDING IN *SOLENOMYA TOGATA.*

In view of the observations formerly made on the mode of feeding in Nucula (see 5, pp. 467–70), similar observations undertaken upon any other Protobranch promised to be interesting. Acting upon a happy suggestion made by Sir E. Ray Lankester, I obtained living specimens of *Solenomya togata* from Naples at the second attempt, and made the following observations. An examination of this delicate little animal through a microscope in water containing carmine particles readily showed that as in Nucula the mantle cavity is divided into two chambers when the animal is feeding. The food-current is drawn into the mantle cavity at the antero-dorsal end and expelled posteriorly (see Fig. 7). During the process of feeding the gills are extended so that their posterior ends touch the mantle postero-ventrally (see Fig. 7), and the lower portions of the gill on each side also meet ventrally, while the tips of the upper lamellæ complete the partition of the mantle cavity by forming a junction with the mantle dorsally. Thus a large anterior inhalent chamber and a smaller posterior exhalent one are formed (as shown in Fig. 9), in the same way as in *Anomia aculeata* and the higher Lamellibranchs. This subdivision of the mantle cavity is of some importance, as it has been regarded by some authors (for example, Sedgwick, p. 345) as occurring only in the higher Lamellibranchiata. It will thus be seen that the whole of the gills of Solenomya resemble generally one lamella of the gill of a mussel for example.

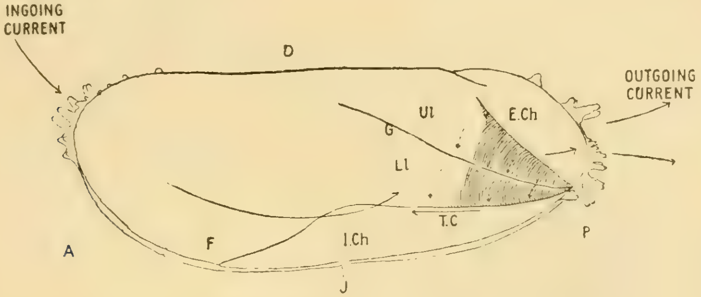

Fig. 9.—View of a living specimen of *Solenomya togata* to show the relations of the gill and the inhalent and exhalent chambers. (× ca. 10.)

G.	Left gill.
I.Ch.	Inhalent chamber.
E.Ch.	Exhalent chamber.
A.	Anterior end.
P.	Posterior end.
D.	Dorsal surface.
U.l.	Upper lamellæ of gill.
L.l.	Lower lamellæ of gill.
J.	Anterior end of the fused portion of the mantle.
T.C.	Region where collected food is transported forwards as shown by the arrow.

The gill of Solenomya, it will be remembered, has the outer and inner leaflets of the same side placed vertically, the one over the other, so that both appear to form one leaflet with a shallow groove along the median lateral line (see Fig. 9). These leaflets are arranged on an axis on each side at the posterior end of body with only the thin edges of the leaflets showing in a side view. The shape of a pair of leaflets may be seen in Fig. 10.

On feeding the animal with carmine grains it was observed that the food-particles collected on the outer faces of the gills were transported quickly to the ventral edges—even from the upper leaflets—and thence carried forwards towards the mouth to be eaten. The collection and transportation of food-particles are effected by means of sets of cilia, but in order to make out the actions of these different sets it is necessary to examine separate living leaflets.

THE CILIATION OF THE GILL OF SOLENOMYA.

When two of the living leaflets (comprising a single pair) of Solenomya are examined microscopically they are seen to resemble in general characters those of Nucula (see Figs. 10 and 11). As in Nucula the main current through the mantle cavity is produced by the lashings of the large lateral cilia on the anterior and posterior faces of the leaflets (see Fig. 10, l.c. and the arrows marked A). Food-particles are collected by the latero-frontal cilia (the presence of which in this species has recently been doubted, see Ridewood, p. 193) and frontal cilia, but transported solely by the latter (see Fig. 10, l.f.c. and f.c.). The latero-frontal cilia lash in a direction across the length of the edges of the leaflets, i.e. away from the spaces between the leaflets

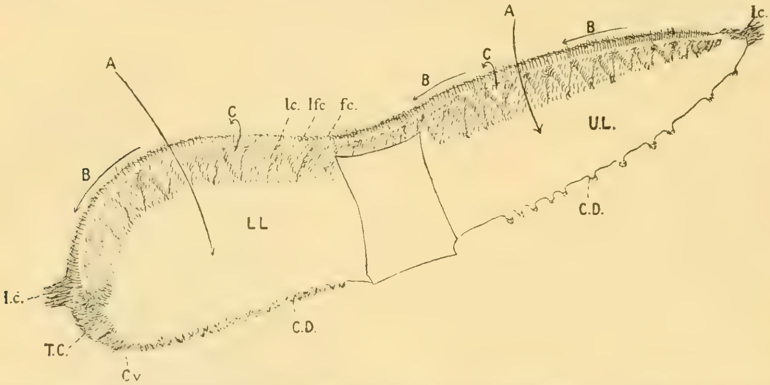

Fig. 10.—View of a pair of living leaflets of *Solenomya togata* taken from about the middle of the gill, to show the directions in which the different sets of cilia lash. (× ca. 60.)

The arrows marked A indicate the direction in which the lateral cilia lash to produce the main current; those marked C indicate the direction of lashing of the latero-frontal cilia which act as food-strainers; while those marked B show the direction in which food-particles are lashed by the frontal cilia.

U.L.	Upper lamella.
L.L.	Lower lamella.
l.c.	Lateral cilia forming a broad band on the side of the gill.
l.f.c.	Latero-frontal cilia.
f.c.	Frontal cilia.
C.D.	Ciliated knobs.
I.c.	Cilia interlocking with the mantle.
T.C.	Cilia which transport food along the ventral edge of the gill towards the mouth.
C.v.	Cilia interlocking with similar ones on the adjacent leaflet.

(see the arrows marked C in Fig. 10). They catch the food-particles which tend to be drawn between the leaflets in the main current and pass them on to the frontal cilia. The latter lash in a ventral direction, and thus send particles along the edges of the leaflets to the ventral surface (see Fig. 10, f.c. and the arrows marked B). Here a group of cilia now lash the food-particles anteriorly towards the mouth to be eaten. As the food-particles are lashed along the face of the gill they become embedded in mucus, which is doubtless secreted by the epithelium of the gill. The secretion of mucus on the Lamellibranch gill is indeed a matter of considerable importance in the feeding process, and it is hoped to investigate the matter more fully later.

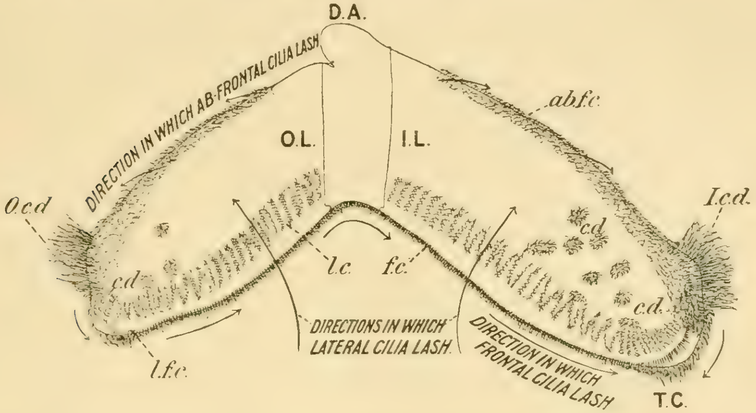
D.A.
DIRECTION IN WHICH AB-FRONTAL CILIA LASH
ab.f.c.
O.L.
I.L.
O.c.d
I.c.d.
c.d
c.d.
c.d.
l.c.
f.c.
DIRECTIONS IN WHICH LATERAL CILIA LASH
DIRECTION IN WHICH FRONTAL CILIA LASH
l.f.c.
T.C.

FIG. 11.—Anterior view of a living pair of leaflets of the right gill of Nucula. (× about 65.) The leaflets anterior to the pair depicted were cut away.

ab.f.c.	Ab-frontal cilia.
c.d.	Patches of cilia on the inner and outer leaflets.
D.A.	Dorsal surface of gill about the 30th pair of leaflets from the posterior end of gill.
f.c.	Frontal cilia.
I.c.d.	Cilia effecting a junction with similar cilia on the left gill.
I.L.	Inner leaflet of gill.
l.c.	Lateral cilia.
l.f.c.	Latero-frontal cilia.
O.L.	Outer leaflet of gill.
O.c.d.	Cilia effecting a junction with the mantle.
T.C.	Cilia which transport collected food forwards.

The examination of single living leaflets reveals a feature of much interest in the ciliation of the gill. On the inner edges of the leaflets, that is, on the ab-frontal surfaces, there occur numerous ciliated knobs (see Fig. 10, c.d.). These ciliated knobs have cilia whose motion is like that of the ciliated discs on the gill-filaments of the Filibranchia (for example see the Fig. of Mussel, Orton, 5, p. 465). This motion may be compared to that of the bristles of two brushes when the brushes are rubbed together slowly in a rotary manner with the bristles interlocking. To get the proper effect one brush should be started rotating before the other, and the bristles should be regarded as vibrating at the same time with a slow wave-like motion which begins at the attached end.

The function of these ciliated knobs is doubtless the same as that of the ciliated discs of the Filibranchia, namely, to interlock with similar discs on the leaflets of the gill on the other side of the body; or, in the case of the anterior leaflets, with cilia on the side of the body of the animal. When suitable material can be obtained sections of the whole gill will be made to show the interlocking of these cilia. The number of ciliated knobs on the gill-leaflets varies in different parts of the gill. Thus in one specimen examined there were only two or three on the anterior upper leaflets and twelve in the corresponding lower leaflets. Behind this point the knobs increase in number, so that at the beginning of about the middle third of the gill there were ten or eleven in the upper and thirty to forty in the lower. In about the middle of the gill there are still more knobs on both leaflets, thirty-five to forty being counted on the upper ones, but the number on the corresponding leaflet was not made out. In front of the posterior end about thirty-six knobs were counted in the upper and eighteen to twenty in the lower leaflets. There are thus more knobs in the middle of the gill and fewer at the anterior and posterior ends, and more in the lower leaflets in the anterior end than in the upper ones in this position, but more in the upper than in the lower at the posterior end. These differences are doubtless explained by the facts that at the anterior ends of the gills the upper leaflets appear to lie against the body, while the lower ones meet below, and thus require a better interlocking arrangement, while at the posterior end of the gill the upper leaflets are longer than the lower ones.

Besides these ciliated knobs there are also other interlocking cilia at the tips of the upper and at the ventro-lateral edges of the lower leaflets (see Fig. 10 I.c.). These cilia doubtless effect a junction with the mantle, and an attempt will be made to obtain sections of the gills and mantle to show these connexions.

On the anterior and posterior faces of the ventral edges of the lower leaflets there are patches of cilia which also have the rotary motion characteristic of interlocking cilia. These probably serve—like the similar patches on the gill leaflets of Nucula (see Fig. 11, c.d.)—to hold the tips of the leaflets together. Thus the living gill of Solenomya is a very compact organ, which, however, like that of Pecten, can be contracted into a small compass so as to leave the inhalent and exhalent chambers continuous.

The characters of a transverse section of a gill-leaflet of Solenomya can now be recognized. Ridewood (p. 193) in describing the ciliation of the gill remarks, " Cilia are confined to the thickened edge, and appear to form a continuous investment of it, not differentiated into frontal and lateral tracts. The material available is not sufficiently well preserved to allow of a definite statement upon this point, but it is worthy of remark that no gap between the frontal and lateral cilia is shown in the figures (of the transverse sections) given by Pelseneer, Kellogg, and Stempell. The cilia extend as far as the level of the outer edge of the thickened chitin bands, and the shortest are those on the frontal surface. Pelseneer shows large latero-frontal cilia, but this is possibly an error."

The foregoing examination of the living leaflets shows that Pelseneer's depiction of large lateral cilia (the latero-frontal cilia) is correct, and that all figures err in depicting a continuous covering of cilia at the tip of the gill (see Fig. 10), thus justifying Ridewood's cautious remarks in this respect. A transverse section may or may not show cilia on the ab-frontal face according as the section passed through a ciliated knob or not. An attempt will be made to make preparations from well-preserved gills and to figure a transverse section.

RESEMBLANCE OF THE CILIATION OF THE GILL IN SOLENOMYA AND NUCULA.

From the above description of the ciliation of the gill of Solenomya it will be seen that there is a close resemblance to that obtaining in Nucula (see Fig. 11). If the frontal surfaces of these gills be compared a complete resemblance in this part is seen; frontal, latero-frontal, and lateral cilia occurring in both and having the same function in both. The ab-frontal cilia of the gill of Nucula, however, are absent from that of Solenomya, and are replaced by ciliated knobs. The small patch of interlocking cilia on the lateral faces of the leaflets of Nucula have not been seen in Solenomya, but a patch of interlocking cilia is present on the ventro-lateral portion of the inner leaflets of both gills (see Figs. 11, c.d., and 10, c.v.). Cilia interlocking with the mantle are present in both forms at the tips of both leaflets; those in Solenomya are, however, nearer to the frontal surface than in Nucula in correlation with the difference in position of the gill in the former. On the whole, therefore, the ciliation of the gill of Solenomya bears a very close resemblance to that of Nucula.

SUMMARY OF THE ACCOUNT OF THE CILIARY CURRENTS IN SOLENOMYA.

The main current through the mantle cavity is effected by means of the lashings of the lateral cilia on the gill-leaflets. This current is drawn in at the antero-dorsal region of the shell and expelled in the posterior region. The food-particles brought to the gill in this current are arrested on the gill by the latero-frontal and frontal cilia, the former passing on particles to the latter. The frontal cilia transport the food-particles along with mucus, which is doubtless secreted by the epithelium of the gill, on to the ventral edges of the lower leaflets, whence a special group of cilia transport the collected particles and mucus towards the mouth to be eaten.* Ciliated knobs occur on the ab-frontal edges of the leaflets which serve to interlock with similar knobs on the fellow-leaflets on the other side of the body. Long interlocking cilia also occur at the dorsal ends of the upper leaflets and the ventro-lateral edges of the lower ones. These cilia serve to effect a junction of the gills with the mantle during feeding, and so divide the mantle cavity into an inhalent and an exhalent chamber.

On the whole, therefore, it is seen that the gill of Solenomya, like that of Nucula, is essentially similar to that of the higher Lamellibranchs. Indeed the presence of numerous ciliated knobs must rank this gill as a more highly specialized one than, for instance, that of *Anomia aculeata*, which has only interlocking arrangements at the tips. Apart from the narrowness of the filaments in *A. aculeata*, there is almost an exact resemblance between the gills of this species and those of Nucula and *Solenomya togata*. Thus the gross structure and the function of the gills in the Protobranchia and the Filibranchia have been shown to be essentially similar, and there can be very little doubt from the published accounts of the gills of other Protobranchia that these may be regarded as essentially similar to those of Solenomya and Nucula.

THE FUNCTION OF THE GILL IN LAMELLIBRANCHS.

The gill in all groups of Lamellibranchs has now been shown to be a feeding organ. Generally, however, this organ is regarded as being chiefly a respiratory and only secondarily a feeding organ. In the light of recent researches on the function of the gill, however, it would appear that the order of importance in which these functions have been regarded must be at least reversed. The expenditure in the gill of the relatively large amount of energy necessary to produce the main current and food currents must enormously outbalance the aerating effect of these currents on the gill. For it is to be remembered that in the gill-filaments of Lamellibranchs the blood is not contained in a capillary plexus, but usually in a blood vessel sunk well below the epidermis. This conclusion with regard to the function of the Lamellibranch gill has indeed already been arrived at, from a morphological point of view, by Dakin (6, pp. 52–3), who states that in the genus Pecten "It seems certain, from the development of vessels in the mantle, that the great function of the gills is to produce currents of water for aeration, nutrition, and the carrying away of waste products, and the only parts of the gills performing any really important duty in respiration are the branchial expansions of the principal filaments." There is little doubt that this statement might now be made similarly of the whole of the higher Lamellibranchs. It is of interest, however, that there is one important difference in this respect in the gills of the Protobranchia. In this group the gill-filaments are broad and lamellate, and contain an extensive space between the two surfaces (see Ridewood, p. 193) over which we have seen the current passes. Doubtless with this type of gill a much greater proportion of the whole respiration is effected in the gill than is the case in the forms with narrow compact filaments. But even here it may be doubted whether respiration is effected to the same degree in the gill as in the mantle. It would be highly interesting in these respects if a ready means could be found of detecting the relative amounts of waste products in any particular part of the body at any particular instant. Such an experiment may perhaps not be an impossibility, as some of these animals can be observed living through a microscope.

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* Since this account was sent to the printer, a paper by E. S. Morse on Solenomya in the current number of the *Biological Bulletin*, Woods Hole, has come to hand. This paper gives an account of observations on living *Solenomya velum* and *S. borealis*. Morse has observed the palps being used for transferring food from the gill to the mouth, which fact, added to those given above, completes our knowledge of the mode of feeding in Solenomya.

APPENDIX.

Some of the observations made in the section on the function of the Wheel Organ and Peri-pharyngeal bands in Amphioxus (p. 25) have already been noticed by Andrews in the Bahamas Amphioxus, as will be seen from the following quotation. It was unfortunately not possible to refer to Andrews' work in the general text, as some difficulty was experienced in obtaining his paper, which only became available after the text had gone to the printer.

Andrews (4) obtained living specimens of the Bahamas Amphioxus

(*Asymmetron lucayanum*) about which he observes: "As the animal is small and translucent, the course of food and carmine granules may be traced through most of the digestive tract. The strong current of water setting into the pre-oral chamber seems to be controlled by the longitudinal, ciliated ridges of Müller's 'Räderorgan' which pass forward from the velum on the inside of each lateral wall of the pre-oral chamber. Thus the carmine granules pass rapidly along these ridges towards the velum, where they are turned inward towards the aperture, mouth, at the centre of the velum. The granules pass along in strings as if held together by a thin mucus; once through the mouth they do not pass out through the pharyngeal slits, but continue along the median dorsal pharyngeal groove, the hyper-pharyngeal groove, still adhering to one another in strings. In actual longitudinal and cross sections these strings of granules may still be recognized in the ciliated hyper-pharyngeal groove.

"This groove leads into what may be called the stomach, within which the current of granules, or the granule containing mucous strand, turns abruptly downwards and forwards as indicated in the above diagram, yet does not enter the diverticulum, but, still under the control of the active cilia lining the digestive tract, passes back again through the centre of the stomach. It is now revolving rapidly in a constant direction from right to left, and continues to do so throughout the next division of the digestive tract, the first or larger section of the intestine. In this part of the intestine the granules, diatomes, etc., collect into clumps separated by the clear part of the continuous mucus-like strand. In this region the intestinal epithelium is especially modified in a zone that became very prominent when staining reagents are used.

"The second, final and smaller part of the intestine, contains pellets of detritus that become successively larger towards the anus, where they have the form of elongated, not spherical, masses that are discharged from the anus as the anal sphincter relaxes from time to time. The mucous strand is here broken, the granular aggregates becoming isolated from one another. These balls or pellets move along but slowly, and give up the revolving motion seen in the first part of the intestine and in the stomach.

"The time elapsing from the addition of carmine to the water to the discharge of carmine containing pellets may be much less than one hour."

It will thus be seen that Andrews has described some of the processes in the subsidiary method of feeding in the Bahamas Amphioxus which is doubtless the same as in the Plymouth Amphioxus. He gives the impression, however, that this is the main method of feeding, but such is not the case, as will have been seen from the foregoing description.

SUMMARY.

The mode of feeding in Amphioxus is effected by—

(1) The maintenance of a stream of water through the pharynx by rows of lateral cilia on the gill-bars.

(2) The throwing out of mucus from the endostyle on to the gill-bars to serve for entrapping food-particles.

(3) The collection of food-particles by rows of cilia on the pharyngeal surface of the gill-bars; these cilia work up the food-particles with mucus into cylindrical masses and transport such masses dorsally into the dorsal groove which carries the collected masses backwards into the digestive tract.

Thus the ciliary mechanisms on a gill-bar of Amphioxus are exactly the same as those on the gill-filaments of some Lamellibranchs, as Pecten, and some Gastropods, as Crepidula.

A subsidiary mode of food-collection is effected in the buccal cavity of Amphioxus by the ciliated tract known as the wheel organ, and Hatchek's pit, which supplies mucus for entrapping food-particles. These particles are passed on to the peri-pharyngeal bands which conduct them in turn into the dorsal groove.

The gill of Amphioxus functions mainly as a feeding organ and a water pump, and probably not at all as an organ for aerating the blood.

The mode of feeding in Ascidians is almost exactly the same as that described above for Amphioxus. Food-collection, however, in Ascidians is effected by cilia on the papillæ and similar outgrowths on the gill, and is also helped in some forms by transverse waving of the longitudinal bars, by which process the food is pushed as well as lashed towards the dorsal region of the pharynx.

The observations here made lend support to the view that the neural gland in Ascidians is an organ for secreting mucus, which aids in the capture and transportation of food-particles, and that the dorsal tubercle of Ascidians is an organ for passing mucus on to the pharynx; the corresponding structures in Amphioxus, namely, Hatchek's pit and the wheel organ, are here shown to effect food-collection in the buccal cavity.

The cavity in the body of Ascidians through which the food stream can pass is maintained by the test, and in Amphioxus by the expansion of stout connective sheaths over the dorsal region of the pharynx held in place by muscular attachments to the dorsal region of the body.

The ciliation of the gill-bars of Balanoglossus is essentially the same as that of Amphioxus. Hence the current of water through the body of the animal is doubtless effected by the lateral cilia and a mode of food-collection effected by the frontal cilia.

Observations on late Ammocoete larvæ indicate food-collection on the gill-bars and the roof of the pharynx, as occurs in Amphioxus. An attempt will be made to complete these observations.

The mantle cavity of *Solenomya togata* is divided into inhalent and exhalent chambers by the gill in the same way as in other Lamellibranchs, namely, Anomia and Pecten.

The ciliation of the gill of Solenomya closely resembles that of Nucula : the lateral cilia produce the main current, the latero-frontal and the frontal cilia collect food-particles, and the latter transport them to the ventral surface of the gill, whence they are conducted forwards by special transporting cilia towards the mouth to be eaten.

Numerous small ciliated knobs occur on the ab-frontal face of the gill-lamellæ and serve to interlock with their fellows on opposite leaflets.

These ciliated knobs correspond to the ciliated discs of the gill-filaments of other Lamellibranchs, for example, the Mussel.

Interlocking cilia occur on the edges of the upper and lower leaflets of the gill and serve to lock the gill to the inner wall of the mantle, and thus to partition the mantle cavity.

The function of the Lamellibranch gill is probably mainly that of a food collector and a water pump, and except in the Protobranchs is probably not an organ in which aeration of the blood occurs.

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The Electrical Conductivity of Fertilized and Unfertilized Eggs.

By

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THE following is a preliminary account of some experiments carried out this summer at Plymouth. They were undertaken with a view to the investigation of the changes, both physical and chemical, which are induced in the egg by the entrance of a spermatozoon.

No attempt is made to discuss the results in the light of current theories regarding the phenomena of fertilization, as it is hoped that further work will make such discussions more profitable than would be the case at present.

APPARATUS.

In order to determine the electrical conductivity of the eggs, a conductivity cell was used such as would fit the holder of a small hand centrifuge. The tube was about 10 cm. long and 1 cm. in diameter. The electrodes were two square platinum plates each possessing two equal surfaces of 25 sq. mm. These were fixed about 25 mm. apart and were carried by two silver wires which passed through glass tubes, and which were fixed through the stopper of the tube.

In some of the earlier experiments the volume of the eggs in the tube was determined by marking their level with a fine pointed grease pencil, but in all the later experiments the tube was graduated.

This form of conductivity cell has two advantages—it fits into the holder of an ordinary centrifuge, and the volume of eggs required is small. The latter point is of great importance, quite apart from the difficulty in obtaining large quantities of ripe *Echinus* eggs. If too many eggs are enclosed within a tube, it is not only impossible to ensure a good percentage of fertilizations by adding a small quantity of sperm, but the overcrowding of the eggs interferes very considerably with the development of the eggs subsequent to fertilization, i.e. the rate of division differs very considerably from that of similar eggs in a large bulk of water; in extreme cases the development ceases at an early stage. In all my experiments, except where specially mentioned to the contrary, the eggs developed normally, although in some cases more slowly than the controls.

The temperature at which the experiments were made never differed much from room temperature, so that it was found possible to keep the temperature of the eggs constant to within $\frac{1}{10}$° centigrade by means of a simple thermostat. The whole apparatus stood in a large earthenware bowl containing water at room temperature.

The alternating current was obtained from a 2-volt accumulator connected to a small induction coil of high frequency. The resistance was measured by means of a Kohlrausch bridge (half a metre in length), and a telephone. The electrodes were platinized in the usual way by means of platinic chloride with a trace of lead acetate. The induction coil was placed outside the room in which the experiments were made, and by keeping the electrodes well platinized it was possible to obtain quite distinct minimal points with an ordinary telephone.

METHODS.

The procedure adopted during the whole of the experiments was as follows: The ovaries of a perfectly ripe female were shaken in one or more finger-bowls containing "outside" water. The ovaries were removed after five or ten minutes, and the sea-water containing the eggs filtered through a suitable piece of bolting silk. In this way any loose pieces of ovarian tissue were removed from the eggs. The latter were now allowed to settle to the bottom of the bowl. The ripe eggs settled somewhat slowly, but after a short time sufficient eggs for one experiment could be drawn off in a clean pipette; thence they were transferred to the conductivity tube. The requisite amount of eggs having been so obtained, the tube was filled up with clean sea-water, corked and allowed to stand in a bowl of sea-water until the eggs had again settled sufficiently for the bulk of the sea-water to be removed. This having been done, the eggs were again washed in clean sea-water. After two or three such washings all the small fragments of tissue smaller than the eggs were removed, and the tube contained nothing but ripe eggs in clean sea-water. After washing in this way the eggs settled somewhat more readily than when removed from the ovary, owing to the removal of the gelatinous ovarian membranes. The conductivity tube containing the eggs was then transferred to the thermostat and left until the eggs had settled to a definite volume which could be estimated without any difficulty. Great care was used to ensure that the eggs settled *uniformly* in the tube; if this precaution is not observed it will be found that repeated estimations of the resistance of the same eggs occupying the same volume give very variable results. It was found possible, however, to collect the eggs in such a way as to obtain uniform readings from repeated observations. To ensure an equal distribution of the eggs is a matter of great difficulty in the case of experiments dealing with resistances below 20 ohms; above this, however, the difficulty can be overcome by patience and repeated washings of the eggs.

The volume of the eggs having been accurately determined by means of the graduation on the tube, some of the sea-water was removed from the tube and the electrodes placed in position and the resistance of the eggs determined.

The electrodes were then removed and the tube filled with fresh sea-water (care being taken not to remove any eggs with the electrodes).* One or two drops of a dilute emulsion of sperm were then added and the tube inverted so as to distribute the eggs equally through the sea-water.

After a minute the tube was allowed to stand in the water of the thermostat, until the eggs had again settled to the bottom of the tube. It was usually found that the fertilized eggs occupied a larger volume than the same eggs unfertilized; in such cases the tube was transferred to a hand centrifuge and *very gently* centrifuged to the required volume. The excess of sea-water was again drawn off and the electrodes placed in position and the resistance of the egg determined. The use of the centrifuge was avoided as far as possible for fear of injuring the eggs; it was found, however, that gentle use of the machine had no effect on the resistance of unfertilized eggs, or upon the subsequent development of fertilized eggs. If, however, the unfertilized eggs were so compacted as to require rather vigorous use of the centrifuge, the experiment was discontinued after the estimation of the resistance of the fertilized eggs. Such eggs were usually found to be crushed although not broken, and when returned to abundant sea-water the large majority developed normally.†

After each estimation of the resistance of the eggs, the conductivity tube was filled with fresh sea-water and immersed horizontally in sea-water whose temperature never differed from that of the thermostat by more than 1° C.

Objections may be raised against the conclusion that the observed differences in resistance of eggs at different stages of development are due to the direct effects of fertilization. The following alternative suggestions might be offered :—

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* When not actually in use the electrodes were kept immersed in clean sea-water.

† These remarks apply to eggs which gave a resistance of 70 ohms and upwards.

1. That the changes are due to the injurious effect of the current upon the eggs. For this, however, evidence is entirely unavailable. Eggs upon which definite and prolonged experiments had been made on June 18th were transferred to a bowl of clean sea-water, all the eggs divided normally, and all gave healthy larvæ. Some of these early plutei were placed in a sterilized jar and fed with a pure diatom culture ; on July 11th the plutei were large and healthy. They had developed at a normal rate, and a definite *Echinus* rudiment was visible. Several such observations of the development of eggs whose resistance had been measured were kept, and in each case the development was perfectly healthy and normal.* It is therefore, I think, safe to conclude that the eggs were unaffected by the passage of the current used in these experiments.

2. That the changes are due to experimental error in returning the eggs to the same volume. To determine the degree of error due to such a source, I made successive determinations on the resistance of the same lot of unfertilized eggs. I found that the variation of the readings never exceeded 2% of the total resistance (in many cases successive readings were identical). Now such a difference might perhaps explain experiments in which the total resistance is below 20 ohms, but is quite inadequate for the much larger differences which were regularly observed for eggs compacted to give higher resistances.

3. That the decrease in resistance of the eggs subsequent to fertilization is due to the presence of the fertilization membrane and not to the substance of the egg itself. It cannot, however, be suggested that the spaces between the egg are enlarged by the membrane, for the unfertilized eggs are not crushed during the experiments, and any crushing undergone by the fertilized eggs is at the expense of the *membrane* and not of the egg. If the eggs are closely compacted after fertilization it is almost invariably found that either the membranes are much wrinkled or are removed entirely from the egg on the addition of fresh sea-water. Again, during the course of the experiments it was found that the fertilization membranes in some batches of eggs were never pushed far out from the egg, but

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* In the case of *Echinus miliaris* plutei, which according to Shearer, De Morgan and Fuchs fail to develop their green pigment if unhealthy, my cultures invariably possessed this character and were, in the opinion of Dr. Shearer, perfectly healthy. (Most of the cultures were discarded as soon as the Echinus rudiment had reached considerable size, but in two cultures which were preserved the larvæ underwent perfectly typical metamorphosis—a little more than a month after fertilization, which is in agreement with the rate of development of the egg under normal conditions.)

remained rather closely applied to the egg-surface; in such cases the resistance of the fertilized eggs was, as in other cases, markedly lower than that of the unfertilized eggs. It was also found that eggs from which the fertilization membrane had been forcibly removed developed quite normally. Now Loeb has shown that the fertilization membrane is permeable to electrolytes, and I therefore conclude from the above facts that the presence of a membrane round the eggs is equivalent to a similar quantity of sea-water, and that when the eggs are reduced to the same volume as before fertilization, the distance between the eggs is identical.

The fact that after the initial fall in resistance of the eggs after fertilization there is a definite and well-marked *rise* in resistance, eliminates the suggestion that the changes observed are due to the presence of a fertilization membrane. Again, in a few cases (i.e. in experiments dealing with high resistances) a considerable number of the membranes are removed from the egg whilst determining the resistance of the fertilized eggs, so that when sea-water is added the membranes are found floating in it. If the eggs are not allowed to settle *at once* they are found still to have a resistance equal to the value obtained by the first determination after fertilization.

4. That the observed differences are due to the existence of free spermatozoa between the eggs. This is not the case, because (1) the addition of as much sperm as was used in any of these experiments does not alter the conductivity of a bulk of water equal to that of the eggs; (2) the conductivity of a concentrated emulsion of sperm is considerably *lower* than that of pure sea-water.

(NOTE.—McClendon states that by repeatedly washing the unfertilized eggs of *Arbacia* he was able to prevent the formation of a fertilization membrane when the sperm entered the egg. I have never observed this in the eggs of *Echinus*, but prolonged washing tends to prevent the membranes being pushed out to their normal extent.)

TABLE I.

EXPERIMENTS WITH *Echinus acutus*.

	Resistance in Ohms of		Minutes after addition of sperm that determination of R_F was made	$R_U—R_F$	$\frac{(R_U—R_F)\,100}{R_U}$
	Unfertilized Eggs (R_U)	Fertilized Eggs (R_F)			
1.	17·3	16·3	6	1·0	5·8
2.	22·5	21·5	10	1·0	4·4
3.	30·0	28·5	10	1·5	5·0
4.	30·5	27·8	12	2·7	8·8
5.	36·5	34·0	15	2·5	6·8
6.	38·0	29·7	6	8·3	21·8
7.	39·7	36·5	10	3·2	8·0
8.	40·5	37·5	7	3·0	7·4
9.	40·6	37·5	9	3·1	7·6
10.	41·0	38·0	8	3·0	7·3
11.	41·5	38·5	3	3·0	7·2
12.	42·8	40·8	11	2·0	3·7
13.	43·0	39·0	10	4·0	9·3
14.	44·0	39·0	15	5·0	11·3
15.	44·0	33·0	2	11·0	25·0
16.	44·0	43·5	13	·5	1·1
17.	45·0	41·0	6	4·0	8·9
18.	45·0	41·0	9	4·0	8·9
19.	45·0	36·5	7	8·5	18·9
20.	46·0	41·0	15	5·0	10·9
21.	47·3	40·5	14	6·8	14·3
22.	49·0	45·0	4	4·0	8·1
23.	49·0	48·0	15	1·0	2·0
24.	50·0	44·0	11	6·0	12·0
25.	50·8	46·0	5	4·8	9·4
26.	51·0	41·5	11	9·5	18·6
27.	51·0	40·0	7	11·0	21·6
28.	54·0	47·0	6	7·0	12·9
29.	54·5	48·7	13	5·8	10·6
30.	66·0	48·7	20	17·3	26·2
31.	72·0	59·5	9	12·5	17·3
32.	75·5	63·0	10	12·5	16·5
33.	80·0	68·5	5	11·5	14·6
34.	85·0	75·0	15	10·0	11·7
35.	87·0	78·0	10	9·0	10·3
36.	100·0	89·0	15	11·0	11·0

Average value of $\frac{(R_U—R_F)\,100}{R_U} = 11{\cdot}2$

TABLE II.

EXPERIMENTS WITH *Echinus miliaris*

	Resistances in Ohms of Unfertilized Eggs (R_U)	Fertilized Eggs (R_F)	Mins. after Fertilization	R_U-R_F	$\frac{(R_U-R_F)\,100}{R_U}$
1.	16·0	15·4	15	0·6	3·7
2.	16·4	15·5	15	0·9	5·5
3.	19·1	17·0	8	2·1	11·0
4.	26·5	25·5	5	1·0	3·8
5.	30·0	29·0	8	1·0	3·3
6.	32·5	29·5	18	3·0	9·2
7.	32·5	31·0	12	1·5	4·6
8.	42·0	39·5	10	2·5	5·9
9.	45·5	41·0	20	4·5	9·9
10.	47·0	40·3	15	3·3	7·0
11.	49·5	45·5	10	4·0	8·1
12.	56·5	41·0	21	15·5	28·0
13.	60·0	56·0	10	4·0	6·7
14.	61·0	51·0	7	10·0	16·4
15.	65·0	50·5	10	15·5	23·8
16.	65·0	55·0	15	10·0	19·4
17.	76·0	61·0	13	15·0	19·7

$$\text{Average value of } \frac{(R_U-R_F)\,100}{R_U}=10{\cdot}9$$

TABLE III.

EXPERIMENTS WITH *Echinus esculentus.*

	Resistances in Ohms of Unfertilized Eggs (R_U)	Fertilized Eggs (R_F)	Mins. after Fertilization	R_U-R_F	$\frac{(R_U-R_F)\,100}{R_U}$
1.	88·0	72	10	16·0	18·2
2.	40·0	37	6	3·0	7·5

TABLE IV.

EXPERIMENTS WITH *Asterias glacialis.*

	Resistances in Ohms of Unfertilized Eggs (R_U)	Fertilized Eggs (R_F)	Mins. after Fertilization	R_U-R_F	$\frac{(R_U-R_F)\,100}{R_U}$
1.	29·0	27·5	12	1·5	5·2
2.	33·0	29·0	15	4·0	12·1
3.	35·5	33·0	10	2·5	7·0
4.	37·5	34·5	15	3·0	8·0
5.	41·5	39·5	8	2·0	4·8

$$\text{Average value of } \frac{(R_U-R_F)\,100}{R_U}=7{\cdot}4$$

TABLE V.

		Resistance of Unfertilized Eggs	Resistance of Fertilized Eggs	
			Within 15 mins. of Fertilization	15–44 mins. after Fertilization
1.	*Echinus acutus*	30·0	28·5 (10)	29·5 (32)
2.	,, ,,	43·0	39·0 (10)	43·0 (38)
3.	,, ,,	46·0	41·0 (15)	43·5 (30)
4.	,, ,,	38·0	29·7 (6)	31·0 (27)
5.	,, ,,	45·5	36·5 (7)	37·3 (28)
6.	,, ,,	51·0	40·0 (7)	41·5 (27)
7.	,, ,,	45·0	41·0 (9)	42 (26)
8.	,, ,,	50·8	46·0 (5)	51 (20)
9.	,, ,,	49·0	45·0 (4)	50·5 (15)
10.	,, ,,	80·0	68·5 (5)	80 (16)
11.	,, ,,	54·0	47·0 (6)	54 (27)
12.	,, ,,	72·0	59·5 (9)	64·0 (27)
13.	,, ,,	42·8	40·8 (11)	42·8 (38)
14.	,, ,,	41·5	38·5 (3)	40·0 (17)
15.	,, ,,	54·5	48·7 (13)	48·7 (30)
16.	*Echinus miliaris*	32·5	29·5 (18)	32·0 (38)
17.	,, ,,	42·0	39·5 (10)	41·0 (44)
18.	,, ,,	65·0	50·5 (10)	52·5 (28)
19.	*Asterias glacialis*	37·5	34·5 (15)	35·5 (27)
20.	,, ,,	33·0	29·0 (15)	30·5 (31)

The figures in brackets in columns 2 and 3 indicate the actual number of minutes after the addition of sperm to the eggs.

CONCLUSIONS.

From these experiments I draw the following conclusions :—

1. That the entrance of the sperm into the egg causes an increase in electrical conductivity of the egg. This condition usually attains its maximum within ten minutes of adding sperm to ripe eggs.
2. That this increase in conductivity is followed by a process which returns the conductivity of the egg to or towards that of the unfertilized egg.

The chief limitation of the method lies in the fact that in order to get a measurable change in resistance between the electrodes after fertilization, the eggs must be concentrated to give an initial resistance of about 30–40 ohms. In order to cover the electrodes with the eggs, at least ½ c.c. of eggs is required. The volume of sea-water which the conductivity cell can hold is about 10 c.c. ; the effect of these conditions is that when the eggs are shaken in sea-water after the determination of their resistance they are so crowded that they develop at a rate different from that of control eggs kept in abundance of water. The change in rate of development varies with different batches of eggs and with their degree of concentration. Hence it is impossible by this method to determine the conductivity of normal eggs (i.e. eggs developing at a normal rate) at any stated moment. As, however, the development of the eggs in the conductivity tube is only abnormal in respect to time (i.e. the cleavage divisions are quite normal but occur at a varying time after those in a control), it may be concluded that the sequence of events in the two cases is the same.

A more important limitation lies in the fact that the resistance can only be determined by concentration of the eggs. We may conclude that when the eggs are concentrated at the bottom of the tube, their development very quickly becomes delayed until the return of normal conditions ; hence it is not possible to take a large number of readings during one experiment.

These two factors would account for the variation found in curves obtained from the individual experiments. For example, most of them show the same maximum and minimum points during the first hour of development, but corresponding points on different curves do not agree in point of *time*. Again, it is almost certain that the primary rise in conductivity due to the entrance of the sperm, lasts only for some fifteen minutes or less ; if therefore it is found impossible (for technical reasons) to determine the resistance of the fertilized eggs during this period, the pronounced minimal point which exists during the first ten minutes of development is entirely lost, and the curve differs radically in appearance from the normal. Owing to the rapid rate in the rise and fall of the conductivity at the commencement of development the exact time at which the resistance is determined is of considerable importance. For example, one experiment gave the following data :—

The resistance of eggs 3 mins. after fertilization was 10·5 ohms less
than that of the unfertilized eggs.
,, ,, ,, 9 ,, after fer. was 12.5 ohms less
,, ,, ,, 13 ,, ,, ,, 3 ,, ,,
,, ,, ,, 25 ,, ,, ,, 8 ,, ,,

In other words, the conductivity of the eggs has undergone profound changes within 13 minutes. It is therefore necessary to discover the position of the maximum and minimum points with considerable accuracy before any quantitative value can be ascribed to the changes in conductivity which take place during the development of the normal egg.

Without wishing to dogmatize in any way as to the explanation of these preliminary experiments, it may be pointed out that they may possibly be due to either purely physical or purely chemical changes in the egg—or to a combination of such causes. The egg in the unfertilized state is remarkably impermeable to electrolytes, and can almost certainly be regarded as being enclosed within a semi-permeable membrane. In its unstimulated condition, this surface must necessarily be polarized. If now this polarization be destroyed, the membrane must become more permeable to ions than before. On this view the entrance of the sperm effects the depolarization of the plasma-membrane. After about fifteen minutes this membrane must become polarized again, but the mechanism whereby this is effected is not at present clear.

On the other hand, if the sperm carries an enzyme into the egg, which acts on some constituent of the egg-cytoplasm, then a rise in conductivity may occur as the result of the liberations of ions from unionized substances ; while a reversal of this reaction will have an opposite effect.

It is hoped that further work will produce sufficient evidence to show which of these two possibilities is the more probable explanation of the experimental data, and a discussion of the results obtained by other workers is therefore postponed.

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Some Rare and Interesting Sea Anemones from Plymouth.

By

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With Figures 1 and 2 in the Text.

THE anemones described in the following pages were collected by Mr. J. H. Orton, and forwarded for examination.

I. **Edwardsia timida,** Quatrefages.

Quatrefages obtained his specimens at Chausey, Manche, N. France, and his descriptions of *E. timida* and *E. harassi* as new species appeared in 1842 ("Ann. des Sci. Nat." (2), XVIII). G. Y. Dixon obtained eight specimens at Malahide, Co. Dublin, and these he carefully described in 1886 (" Proc. Roy. Dublin Soc."). He also united Quatrefages' two species as *E. timida*. In 1889 A. C. Haddon supported Dixon's opinions and identification, gave a good figure of the mesenterial muscle characters, and contrasted these with three other British species (" Proc. Roy. Dublin Soc.").

Through the kindness of Dr. E. J. Allen and Mr. J. H. Orton, B.Sc., we have been able to examine and identify a specimen from Plymouth Sound, obtained May 22nd, 1912. This specimen was examined when alive, when killed expanded, and also anatomically by means of transverse sections.

Size.—Measurements during life were difficult to obtain as the Anemone was very timid and remained buried in sand, only expanding the tentacular crown at the surface. The latter was 12 mm. in diameter. When killed in an expanded condition, the total length was 41 mm.; length of capitulum 9 mm., diameter 3·5; diameter of scapus 4 mm.

Form.—Physa not large, and when partially invected showed eight well-marked divisions; no attached sand grains. Scapus elongate, cylindrical, tapering below and somewhat inflated at the summit, covered by a thin coat of mucus and a number of attached sand grains; body-wall slightly wrinkled transversely and divided into eight regions by the grooves along the insertion of the mesenteries ; there is a tendency to folding, and suckers are present on the upper portion. The capitulum, arising from the scapus by a gentle slope, was retractile, delicate, and smooth. Disk concave ; mouth raised on a cone. Tentacles 16 in number, of fair length and somewhat obtuse ; at first sight there appeared to be 17 tentacles, but this was due to the fact that one was bifurcate near the summit.

Colour.—Investing coat yellowish ; during distension, the mesenteries showed through the integuments as white longitudinal lines. Disk light brown, freckled with yellowish white spots, the eight radii yellowish white with a dark central line ; lips of a darker shade of brown than the disk and with a circle of eight reddish brown spots. Tentacles pellucid, freckled, and indistinctly and irregularly barred and blotched with white, and with a few distinct madder-brown or chocolate spots, which tended to become bars near the tip : at the base of one of the tentacles was a white spot. The colouration of the disk and tentacles harmonized so exactly with that of the sand amidst which the Anemone was living as to render it by no means easy of detection, even when fully expanded.

Anatomy.—Transverse sections showed muscle characters practically identical with those figured by Haddon. The ectoderm is thin, and broken in many places ; the mesogloea is fairly thick, not very dense, and contains here and there lenticular spaces of no great size ; these stain deeply. The endoderm is of about the same thickness as the mesogloea, and both broaden in the regions between the insertion of the mesenteries.

The specimen was a female, and the mesenteries were all gonophoric. In the basal muscle the mesogloea shows eight to ten folds on either side, many of them branched ; the longitudinal muscles large and with from eighteen to twenty folds, a number of which are more or less branched ; all are fringed, giving them much the aspect of fern fronds. The ova occurred as more or less compact masses.

II. **Edwardsia claparedi,** Panceri, 1869.

Haddon (1889) suggested that the *Edwardsia* which Kingsley found washed up at Torquay in 1854, and which was described by Gosse (1860, p. 262) as "? *Edwardsia beautempsii* (Quatref.)," may have been *E. claparedi*. After stating his belief that *E. callimorpha*, Gosse, is identical with *E. beautempsii*, Quatrefages, Haddon enumerates the points of difference between that species and the specimen in question as given by Gosse, and concludes : " In the above particulars this *Edwardsia* agrees so well with the description and beautiful figures of *E. claparedi* (Panceri) given by Professor Andres (*Le Attinie*, p. 90, pl. xi.) that we may with justice, for the present, allocate it to that species."

After examination and comparison of both external and anatomical characters, we are able to identify as *E. claparedi* two specimens from Plymouth; and the species can thus be added to the British Fauna with certainty.

Of the two specimens just mentioned, one (A) was kept alive for a considerable time at Plymouth, was safely sent to us at Aberystwyth, and remained in a healthy condition, living buried in sand in a shallow dish. When first received it was very timid and remained buried for twenty-four hours, expanding at first only by night, and closing rapidly at the least vibration. Later it would remain expanded during daylight and for much longer periods, and it also became much less sensitive to movements in its vicinity. Both specimens were obtained from Jennycliff Bay, Plymouth Sound.

Size.—It was impossible to obtain complete measurements of (A) during life, as it remained buried, and if uncovered retracted and at once commenced to bury itself by the use of the physa. When partially anæsthetized the total length was 50 mm.; greatest diameter of scapus 7·5 mm.; of capitulum 4 mm.; the physa was 4 to 5 mm. in length and breadth; and the expanse of the tentacular crown 12 to 13 mm. The physa was rounded, delicate in texture, and almost transparent. Scapus cylindrical, fairly stout, tapering downwards to just above the physa, ringed and folded during partial retraction; grooved by the insertion of the mesenteries, with the intervening ridges warted. Scapus covered by a thin cuticle which is thickest on the ridges and about the warts; these latter occur in a linear row on each ridge and are seldom contiguous; the upper third of the scapus is bare of cuticle and the warts are fewer and finally disappear. The capitulum and upper portion of the scapus can be retracted within the remainder of the scapus, and this movement can be very rapidly effected. The tentacles are sixteen in number, slender, tapering, about twice as long as the diameter of the disk; held in a most irregular manner as a rule, some extended, others flexed, others bent in a contorted manner across the disk; occasionally all are regularly extended, the tips bent inward (as shown in Fig. 1).

Colour.—Physa almost transparent. Cuticle rust-red, but darker where thickest (as around the warts). On the summit of the warts the cuticle is frequently missing and they then appear as pale spots. Capitulum dull opaque flesh colour, near the summit is an indistinct white ring, and above this an indistinct circle of purple. Disk fawn, with some orange mottlings about the mouth region; an indefinite white area runs from the base of the two opposite "gonidial" tentacles toward the lips, and from the bases of the remaining six tentacles of the primary cycle run similar indistinct black bars, these radial markings divide the rest of the disk into eight more or less irregular fawn-coloured, triangular areas; the mesenteries also show as pellucid white lines. Mouth usually elevated, lips pale. Tentacles translucent, blotched with opaque-white and speckled with small red dots, the tips white: the white mottlings appear mainly on the front face.

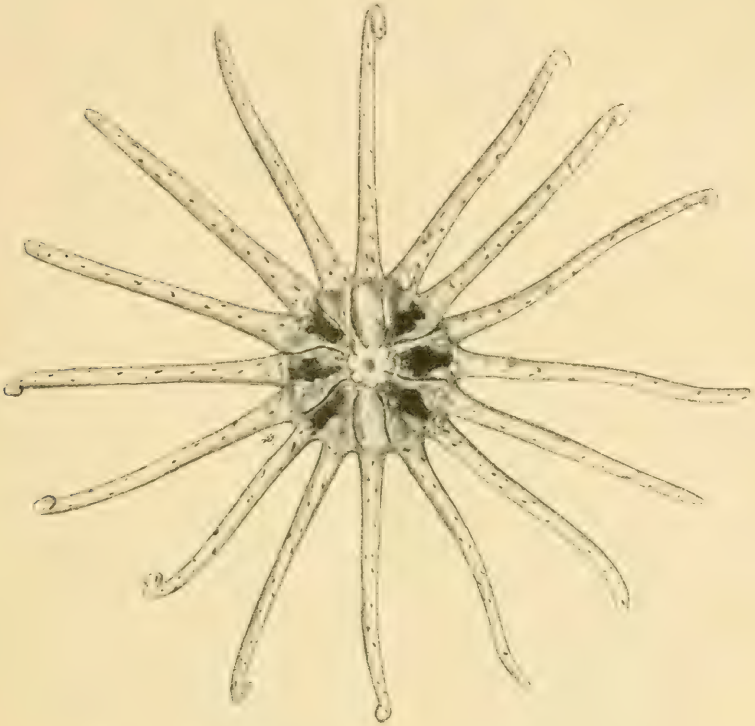

FIG. 1.—*Edwardsia claparedi.* Oral disk (greatly enlarged).

Specimen (B).—A preserved example, obtained from mud, Jennycliff Bay, April 12th, 1912. It was strongly contracted, and somewhat damaged. Cuticle thin and brownish in colour, the mesenteries showed here and there through the body-wall in an indistinct manner; capitulum and physa invected; eight warted ridges were present, but not so strongly developed as in the last example. Length 28 mm., breadth about 8 mm.

We have compared these Plymouth examples with preserved specimens of *E. claparedi* obtained from the Naples Marine Biological Station, and find both external and internal characters in agreement. The following is a short description of the external characters of one of the best of the Italian specimens :

Length (somewhat contracted) 45 mm., greatest diameter 5 mm. Physa small, being slightly contracted, about 1·5 mm. in length. Scapus cylindrical, tapering at either extremity, coated by a wrinkled, orange-coloured epidermis, and beset with eight longitudinal rows of whitish warts, devoid of covering at their summits ; they are set more closely

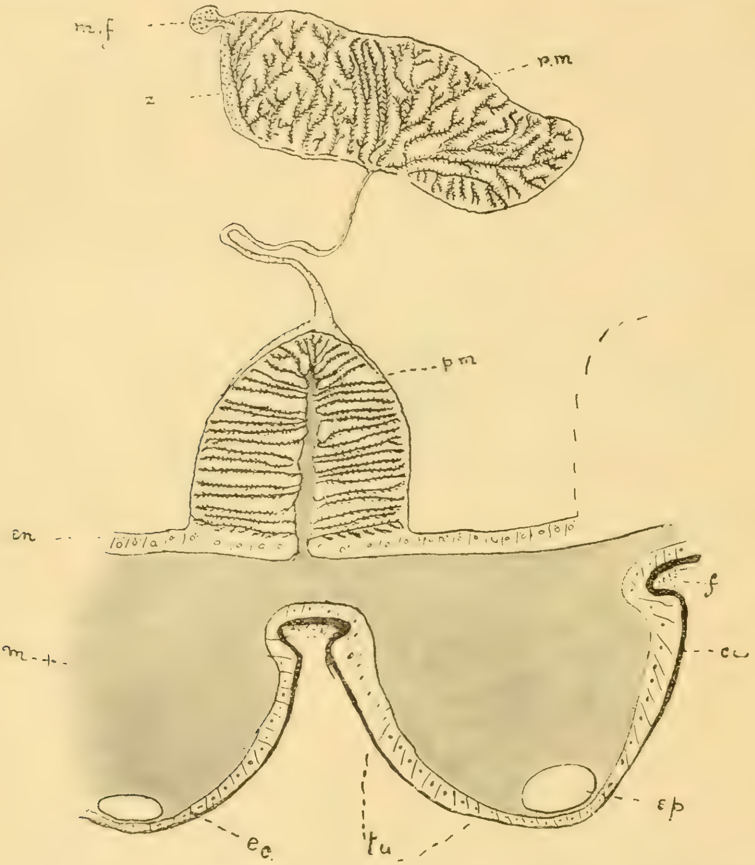

Fig. 2.—*Edwardsia claparedi.* Part of transverse section through the scapus regio showing tubercles, body wall, and mesentery (slightly diagrammatic). *Index to lettering:* *cu*, cuticle ; *ec*, ectoderm ; *en*, endoderm ; *m*, mesoglœa ; *m.f.*, mesenterial filament ; *f*, foreign incrustations on the body-wall ; *sp.*, space at summit of tubercle ; *p.m.*, pariet a muscle ; *r.m.*, longitudinal retractor muscle ; *tu*, tubercle ; *z*, zooxanthellae.

together on the upper third, but scarcely ever contiguous. Disk narrow, mouth pouting. Tentacles 16, obtuse, wrinkled, contracted to a length of 3 mm.

All specimens likewise agree with the figures and description of Andres, and the plate given by Delage and Hérouard in *Zoologie Concrète.* The colouration of this species is evidently extremely variable to judge by the figures and descriptions of Andres in *L'Attinie.*

Anatomy.—Transverse sections of the two British and an Italian example revealed practically identical characters. (B) was strongly contracted and somewhat injured and gave very indifferent results when sectionized. Sections showed the cuticle and a thick but irregular ectoderm (Fig. 2); the mesoglœa of the column wall is comparatively thin in the capitular region, but becomes very dense and much thicker toward the physa end; the warts consist of outgrowths of the mesoglœa and are frequently hollow, being then capped by a thin layer of mesoglœa and ectoderm. All eight mesenteries are fertile; the retractor muscle is large and the basal muscle comparatively small in the region bearing the gonads; lower down, the retractor becomes smaller, and the basal muscle larger, and in the region of the physa the two are of about equal size. The folds of the basal muscle are about twenty in number on each side and are often bifurcated, the proximal fold gives off numerous small branches on its outer edge; the folds are long and slender and lie practically at right angles to the central strand of mesoglœa, which appears in section as a fairly stout rod, branching out at its distal end. The longitudinal retractor muscle is reniform in section, but the folds are not as stout nor have they the peculiar moss-like appearance seen in *E. timida;* they are fairly slender, very much branched, and are from fifteen to twenty in number. We are indebted to Mr. F. S. Wright for a figure of this Anemone in the living condition (Fig. 1).

III. **Halcampa chrysanthellum,** Peach.

Originally described by Peach and Gosse from Cornish specimens, and regarded as the only British species until Haddon discovered *H. arenaria* in S.-W. Ireland in 1885 and 1886. As the two species bear a considerable external resemblance it is more than likely that there has been some confusion in identification. Haddon identified specimens from the East of Ireland as *H. chrysanthellum*, with certain anatomical characters, but he pointed out that, until specimens from the original Cornish localities had been examined anatomically it would be unsafe to assume actual identity. If the Cornish form should prove to be identical with the Irish specimens considered to be *H. chrysanthellum* by Haddon, well and good; it is also possible that *H. arenaria* has a much wider range. Meanwhile many identifications can only be accepted provisionally. British records of *H. chrysanthellum* include: Fowey (Peach); Gwyllyn Vase, Pennance, etc. (Cocks); Salcombe (Allen and Todd); River Yealm ("Plymouth Marine Invertebrate Fauna"); Isle of Man (Herdman); East of Ireland (Haddon); Firth of Forth (Leslie and Herdman), etc.

In 1907 one of us examined some twenty living specimens of *Halcampa* collected in the River Yealm. Considerable variability was noted as to incrusting sand, the retractility and size of the physa, and the colouration. Lack of time unfortunately prevented any further inquiry on that occasion. Recently, however, three preserved specimens collected in the Yealm were examined and found to agree in all external features. Sections have been cut, and the anatomical characters compared with Haddon's figures of his East Irish specimens and found to be identical. It is noteworthy that both Haddon and Gosse state for this species that the physa is large and non-retractible, and this character should prove to be a useful aid to identification. The following is a description of the external characters of the specimen examined anatomically (preserved in spirit): Total length 20 mm., divided as follows: physa 3·5 mm. long and 3·5 mm. broad, scapus 13 mm. × 2 mm., capitulum 3·5: Physa globular, delicate, semitransparent, studded with small white suckers to which adhered numerous sand grains; Scapus slightly wrinkled; Disk convex, elevated, M-mark on the margin distinctly visible.

In another specimen 31 mm. in length the physa was similar in form and showed the same numerous small white suckers and attached sand grains.

IV. **Halcampa arenaria**, Haddon.

This species was described by Haddon in 1886 from specimens obtained from the Kenmare River, S.W. Ireland, 38–44 fathoms (1885), and again, mouth of Bantry Bay, 38 fathoms (1886). We are indebted to Mr. J. H. Orton for a specimen from Rum Bay, Plymouth Sound, November 19th, 1910. He further provided us with some interesting sketches made while the anemone was alive. In his opinion this specimen was *H. arenaria*, and our anatomical examination has proved this to be correct. The following notes describe the specimens after preservation. Total length 38 mm., greatest diameter of scapus 4·5 mm., of capitulum less. Body-wall thick, tough and opaque ; physa damaged, but appears to be much smaller than in *H. chrysanthellum*, no sand grains were attached, and no suckers were observable with a lens ; the small size is well shown in Mr. Orton's sketches, as is also the fact that the physa is retractible in this species, and thus agrees with the plate and description of Haddon (Proc. Roy. Dublin Soc., 1889). The scapus tapers at either extremity, and for a length of 20 mm. is coated with sand grains attached to suckers, and within this portion the physa and capitulum can be withdrawn. The capitulum is smooth, more delicate, and somewhat constricted near the summit.

Colour, pale yellowish buff, the mesenteries showing indistinctly as paler lines. Tentacles and disk much as in *H. chrysanthellum ;* one of Mr. Orton's sketches, comprising a tentacle and portion of disk and mouth, shows the transverse bars, M-mark and the triangular brown patches figured by Haddon ; but the form of these brown marks on the disk is different. Instead of being " lenticular " the marks are triangular, with the apex directed toward the tentacle.

Haddon gave a comparison of the anatomical characters of the two species of *Halcampa*, but a re-statement of the points of difference seems advisable : and ignoring for the present the colouration of the disk and tentacles, the details are here given :—

H. chrysanthellum.	*H. arenaria.*
(1) Physa large, globular, translucent, provided with small white suckers, and not capable of being withdrawn within the scapus.	(1) Physa smaller, probably without suckers, and retractible within the scapus.
(2) Scapus smooth.	(2) Scapus with suckers to which adhere sand fragments forming a more or less dense covering.
(3) Number of folds of the muscular epithelium of the longitudinal muscle of the mesenteries, as seen in transverse section, 10 to 12.	(3) Number of folds of longitudinal muscle about 15.

In addition to the above Haddon states that :—

(4) " The oesophagus in section is, relatively to the diameter of the body, much larger in *H. chry-*

santhellum than in *H. arenaria.*” This character is, however, not well marked in our sections.	
(5) Also, “In *H. chrysanthellum* only 6 mesenteries bear generative products.” This is the case in our specimen.	(5) “All 12 mesenteries are fertile in *H. arenaria.*” In the specimen we have examined only 10 perfect mesenteries are fertile, those that are barren being those mesenteries of the perfect lateral pairs which are nearest to the sulcar directives (the sulco-sulcar laterals of Haddon)

V. **Eloactis mazeli**, Jourdan.

In 1892 Garstang described a living specimen of this interesting Anemone from the Devonshire coast (*Trans. Devon. Assoc.*). Since then, more or less mutilated specimens have been dredged by the s.s. *Oithona* from the Inner and Outer Rame-Eddystone trawling grounds; and during May, June, and July, 1912, in particular, a number of examples were brought in. Almost all were much damaged, only the summit of the scapus and oral crowns being present, and these greatly distorted and contracted. Under these conditions, the tentacles being much shortened and strongly capitate, and the colouration very pale, it was only quite recently that their true identity was recognized. Several when examined still showed signs of life. As in the case of *Edwardsia claparedi* we have compared the Plymouth examples with named material from Naples both as regards external and anatomical characters. The mutilation is evidently due to the habit of lying buried in sand, the oral crown projecting, and thus being cut off by the dredge.

The following is a description of one of the least damaged specimens: *Form.*—Upper portion of scapus firm and smooth, but with many fine longitudinal ridges and grooves, succeeded by a fosse. Tentacles 20, set in two cycles of 10, long and short thus alternating; they consist (in this contracted state) of a stout, transversely wrinkled stalk and a strongly adhesive rounded head. Disk very tumid and much wrinkled; mouth rather large, one strong œsophageal groove. *Colour.*—Flesh tint, the tentacles marked with brown near the summit; disk orange-pink with somewhat lighter rays. Diameter of disk and tentacles 4 cm. when strongly contracted. Locality, 5½ miles off Rame Head; 25 fathoms, fine sand; taken in fine-mesh dredge.

Mr. Orton sends the following notes regarding a specimen obtained from the Outer Rame-Eddystone, July 2nd, 1912 : "The tentacles were blotched with brown at the extremity, and several had double purple internal stripes ; others appear to have only one coloured stripe ; body-wall orange . . . the tentacles were examined but no knobs were visible."

A more detailed description of this species will be found on pp. 70–80.

On Eloactis mazeli.

By

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With Figures 1–4 in the Text.

JOURDAN was the first to describe *Eloactis mazeli.* In 1880 he published *Recherches zoologiques et histologiques sur les Zoanthaires du golfe de Marseilles* (1), and in this paper *E. mazeli* is described under the name of *Ilyanthus mazelii.* Jourdan obtained his specimen from the muddy sand of the north-eastern part of the Gulf from a depth of 60–80 metres. He compares its external characters with those of Peachia, Ilyanthus, and Halcampa ; the following is a translation :—

"In form it approaches Peachia, from which it differs through the absence of gonidial tubes. In the absence of terminal pores and in the smoothness of the column it resembles Ilyanthus, while its cylindrical form recalls that of Halcampa, though it differs from this genus in that it lacks tubercles and a terminal swelling. Its buccal disc is conical, of an orange tint striped with darker lines which run from the mouth to the bases of the tentacles. These last are twenty in number and are arranged in two cycles ; they are white with brown apices and the inner ones are smaller than the external ones."

"The column is cylindrical, and is orange-red with paler lines which run down from the summit in the spaces intervening between the outer tentacles. The basal region is lighter in colour and more membranous ; it is non-adhesive, and the lower part of the column wall is often pushed in, giving the base the appearance of being sunk in. Longitudinal and transverse sections of the basal region show that this sunken portion has no aperture."

Jourdan could not study the structure much owing to the state of preservation of his one specimen, also he was working in the early days of the serial-section method. He was therefore unable to make out the arrangement of the mesenteries, and thus could not place the animal in its correct systematic position.

In 1884 Andres, in *Le Attinie* (2), gave the following description of

E. mazeli, placing it in the Heteractiniæ with *Eloactis globosa*, *Ropalactis*, *Ragactis*, *Heteractis*, and *Stauractis*.

The base, he says, is "slightly adherent, often with a rounded vesicle resembling a physa. Column long, cylindrical, sulcated by 20 invections of slight depth, often minutely rugose; membranous, delicate, scarcely adhesive. Disk small. Tentacles few, bicyclic 10 : 10; the length of the tentacles of the external cycle twice that of the tentacles of the internal cycle; not entirely retractile, rounded at the tips; outwardly deflexed. Peristome low, rounded, concave and grooved. Mouth often prominent. No acontia. Gonidia somewhat open. Pharynx often protruded and resembling numerous angular lobes. Size fairly large." . . .

Delage and Hérouard (6), in 1901, described *Eloactis mazeli* thus: Eloactis is an Actinian which appears to vary in form because of its marked contractility; the base is only slightly adherent, if at all; the column is smooth or rugose according to the state of contraction; it is deeply grooved longitudinally; the tentacles are few in number and arranged in two cycles; they terminate in a rounded swelling rich in nematoblasts; there is no sphincter.

Delage and Hérouard also place it in the Heteractidæ (Andres) Heteractinæ, 11th family; but they say that the family is probably highly artificial, uniting provisionally several Actinians, concerning the anatomy of which very little is known. They all have a smooth and striated but not verrucose column, and tentacles arranged in various ways, but not branched, and armed by swellings rich in nematoblasts.

In 1892, Garstang described a living specimen of this interesting anemone from the Devonshire coast (*Trans. Devon. Assoc.*). Since then several specimens have been dredged from the neighbourhood of the Eddystone and the South Devon coast (cf. p. 68). Almost all were damaged, only the summit of the scapus and oral crown being present. and even these were greatly distorted and contracted. Under these conditions the tentacles were much shortened and strongly capitate; the coloration of these specimens was usually of little intensity. Some of the specimens still showed signs of life.

The present paper embodies the results of an investigation of specimens dredged off South Devonshire, and of one perfect specimen from the Mediterranean. It is sought—

(1) To establish the identification of the British specimens as specimens of *E. mazeli* (Jourdan).

(2) To demonstrate the affinities of Eloactis with certain other Actinian types.

External Characters of E. mazeli (Jourdan).

The following description of the external characters of *E. mazeli* (Jourdan) is based on an examination of a preserved specimen from Naples. Length of scapus, 47 mm.; it tapers gradually downwards. Diameter at summit of scapus, 11 mm.; diameter at base, 7 mm. The base, which is slightly enlarged, is very similar to that of Peachia, being invected somewhat in the centre to a depth of several mm. Upper margin well demarcated, surface of scapus without tubercles, but very much folded and wrinkled and thrown into numerous complex ridges. Tentacles, 20 in two alternating cycles of 10 each, the outer the longer. In this specimen they are contracted, rather stout, tapering slightly upwards and then expanding into a globular or ovate head. Length of outer tentacles 10 mm., inner 4 or 5 mm. Colour, greenish white (in spirit). The tentacles are mottled with dark purplish brown blotches. These become larger and confluent higher up, and in the contracted tentacles appear as slightly raised vesicles or blisters. On the head of the tentacle these marks are of a paler brown suggestive of a less degree of contractility. The disk is narrow and concave; the mouth pointed and prominent.

Internal Structure of the Italian Specimen of E. mazeli.

The mesenteries are twenty in number, and are all perfect and fully developed. Their arrangement is very simple, the mesenteries arising in pairs and two of these pairs are directives (Fig. 1). The longitudinal muscles of each pair are on the faces which look towards the intramesenterial spaces, except in the case of the four directive mesenteries whose longitudinal muscles are on the faces which are turned towards the adjacent intermesenterial spaces. There is only one siphonoglyphe, and this is deep and well defined. The surface of the stomatodæum possesses numerous ridges which increase the digestive area. The body wall consists of ectoderm, mesoderm, and endoderm in almost equal proportions. The ectoderm has a corrugated appearance on its outer surface owing to the body wall being slightly contracted. The mesoglœa is fibrillar, especially towards the inner surface, as in Halcurias.

Jourdan, in his description of the internal characters of Eloactis, also shows the fibrillar nature of the mesoderm: " Sur les coupes transversales le picrocarmin colore vivement le mesoderme et permet d'y distinguer deux zones, l'externe composée de tissu conjonctif lache, l'interne formée de tissus lamineux" ("In transverse sections, the mesoglœa is deeply stained

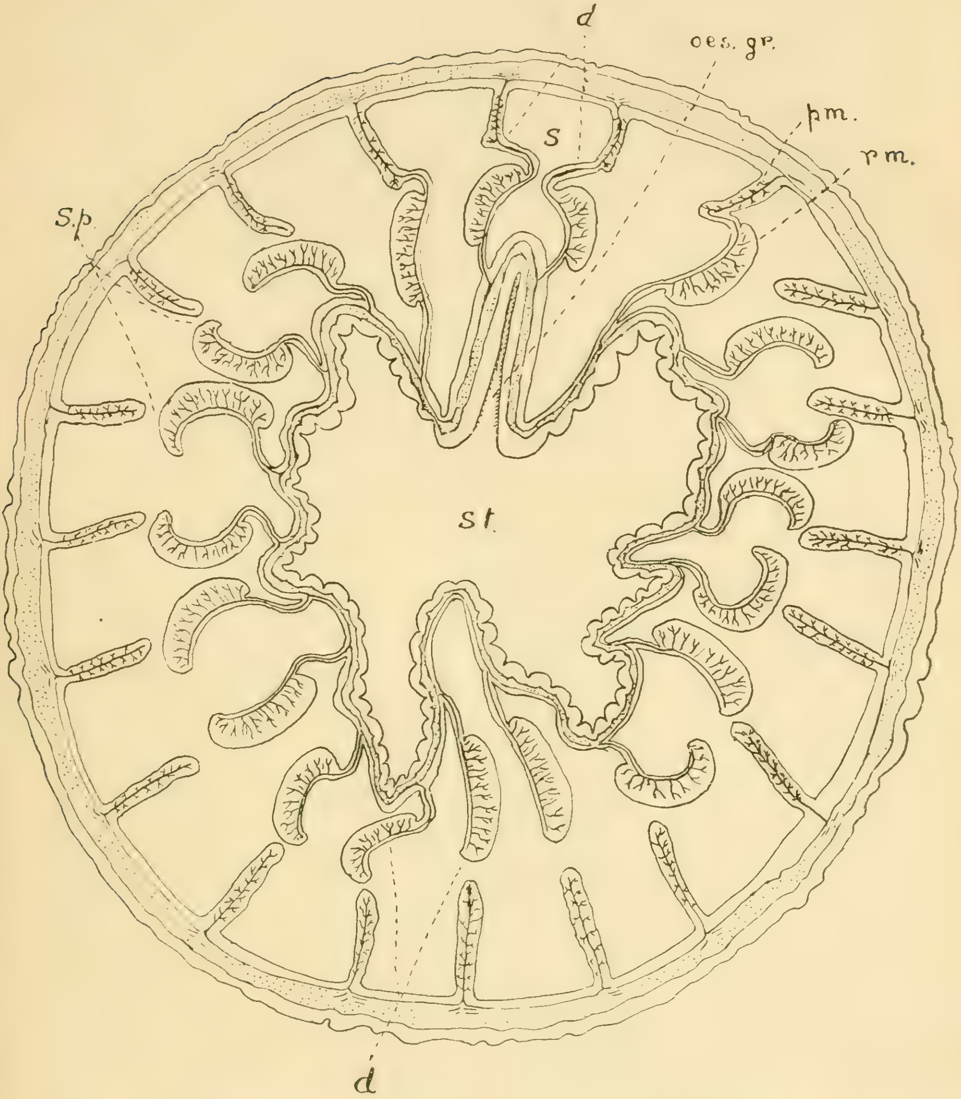

FIG. 1.—Transverse section through the column, showing stomatodæum with œsophageal groove, and septostomes in all the mesenteries except in the sulcar directive and in two sulco-lateral mesenteries: *d.* directive mesenteries, *œs.gr.* œsophageal groove or siphonoglyphe, *p.m.* parietal muscle, *r.m.* retractor muscle, *s.* sulcus, *s.p.* septostomes, *st.* stomatodæum.

by picrocarmine showing two zones, the outer composed of loose conjunctive tissue, and the internal zone of laminated tissue"). The mesoglœa, however, cannot be said to be in two zones, although the inner portion is seen to be more fibrillar than the outer. Then endodermal cells have a granular appearance owing to the presence of zooxanthellæ, which are very numerous near the free surface. Towards the mesoglœa the endoderm seems to become much weaker, the cells becoming spongy and containing no algal cells. In fact, there is a tendency to form an endodermal canal. The whole body wall is comparatively narrow, and very compact, with no lacunæ and no inclusions, and also no nematocysts. It is to be noted that nematocysts are present in the outer portion of the ectoderm of the body wall of Halcurias. The parieto-basilar muscle is very much more elongated than in the Edwardsidæ, and is somewhat like a hart's tongue fern leaf, the midrib being very stout and giving off short much-branched lateral veins on either side. The retractor muscle is pear-shaped and there are between 26 and 30 slender, much-branched folds. Each muscle fold on careful examination shows a definite central strand, as in the folds of *Edwardsia timida*, with an irregular layer of tissue on either side, so that the whole fold has a similar appearance to that of *E. timida*. The folds of Eloactis are, however, more slender than those of *E. timida*, and the whole longitudinal retractor muscle of *E. mazeli* resembles that of *Peachia hastata*. In *P. hastata*, however, the retractor muscle is rather more elongated in section. The muscle folds are numerous and more slender, and the whole is not so distinctly marked off from the parieto-basilar muscle. In the region below the stomatodæum the parieto-basilar muscle becomes much shorter and the muscle folds are longer and less arborescent, while the distinction between the parieto-basilar and the retractor muscles is more indefinite, and the muscle folds become numerous and more slender. The mesentery is continued at its distal end into a mass of sterile tissue, the cells of which contain zooxanthellæ. A very thin filament of mesoglœa is continued through the centre of the sterile mass, and in places this filament opens to form small bulbs with cells of zooxanthellæ. All the mesenteries give rise to this sterile tissue. This suggests that in a fertile specimen all the mesenteries would behave alike and would thus give rise to twenty gonads. In Halcurias also all twenty mesenteries are fertile. There is one œsophageal groove as in Halcurias, but in *Eloactis mazeli* the groove is deep and well defined; whereas in Halcurias the siphonoglyphe is said to be neither very deep nor well defined. In *E. mazeli* the ectoderm of the siphonoglyphe consists of large elongated columnar cells containing

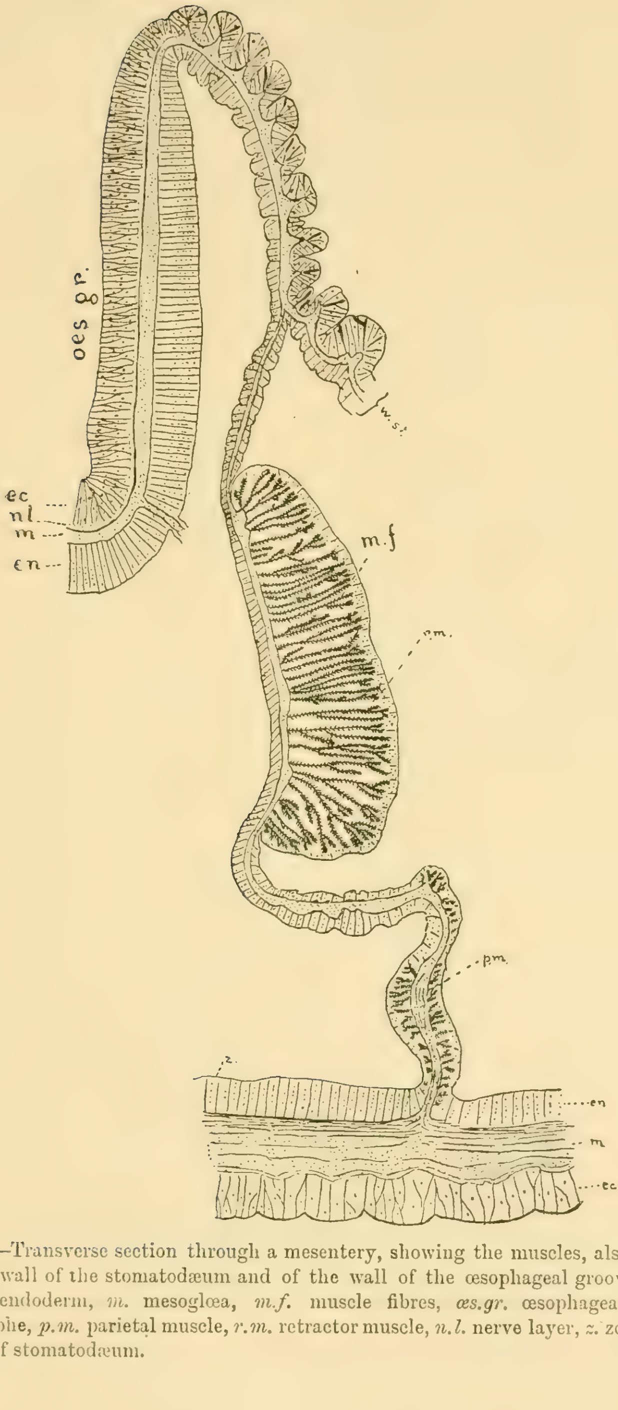

FIG. 2.—Transverse section through a mesentery, showing the muscles, also the structure of the wall of the stomatodæum and of the wall of the œsophageal groove : *ec.* ectoderm, *en.* endoderm, *m.* mesoglœa, *m.f.* muscle fibres, *œs.gr.* œsophageal groove or siphonoglyphe, *p.m.* parietal muscle, *r.m.* retractor muscle, *n.l.* nerve layer, *z.* zooxanthellæ, *w.st.* wall of stomatodæum.

large nuclei, and they are slightly granular and ciliated. Between the ectoderm and mesoglœa is a very delicate layer containing the nerve cells. The mesoglœa in this region is denser and more uniform than that of the body wall, and it is not fibrillar.

The ectoderm of the stomatodæum is distinctly corrugated. The cells are large, and many of them contain colonies of zooxanthellæ. The whole wall of the œsophagus is thrown into ridges like those described and figured by McMurrich in his description of Halcurias (3). A transverse section through the lower region of the column shows the body wall with twenty short mesenteries, each consisting only of an elongated form of the parieto-basilar muscle. Longitudinal sections of the oral disk were examined. The ectoderm is spongy and contains a few colonies of zooxanthellæ. No nematocysts are present. The mesoglœa sends up folds into the ectoderm, except at the points where the mesenteries are attached to the disk. The endoderm contains a few scattered cells of zooxanthellæ. From longitudinal sections of a tentacle (Fig. 3) it is seen that the ectoderm is very thick at the tip, and contains numerous nematocysts. In this region zooxanthellæ are almost absent. This ectoderm causes the swollen tip of the tentacle (Fig. 4*a*). Lower down the zooxanthellæ become more numerous (Fig. 4*b*), and are seen in the ectodermal cells as colonies of pigmented bodies of a greenish yellow colour. The presence of these algal colonies accounts for the blotches described on the exterior of the tentacles. Near the base the ectoderm is less thick, and in places contains neither nematocysts nor

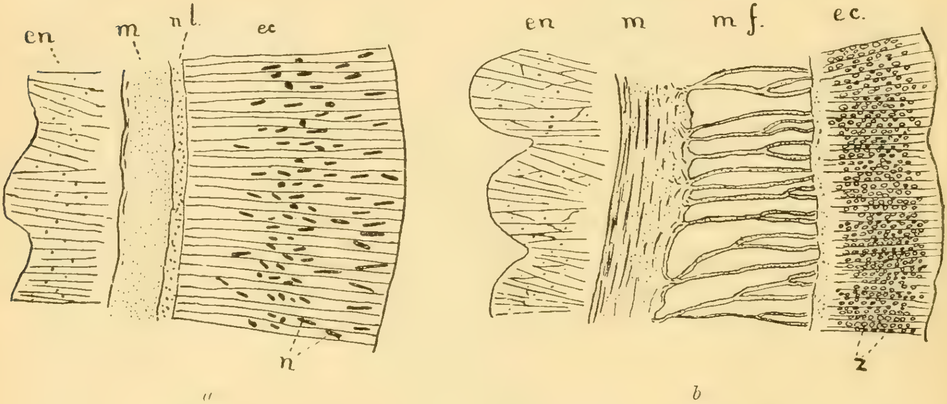

FIG. 4.—Transverse sections through a tentacle, showing structure of wall: (*a*) near the tip, (*b*) near the base; *ec.* ectoderm, *en.* endoderm, *m.* mesoglœa, *m.f.* muscle fibres, *n.* nematocysts, *n.l.* nerve layer, *z.* zooxanthellæ.

3.

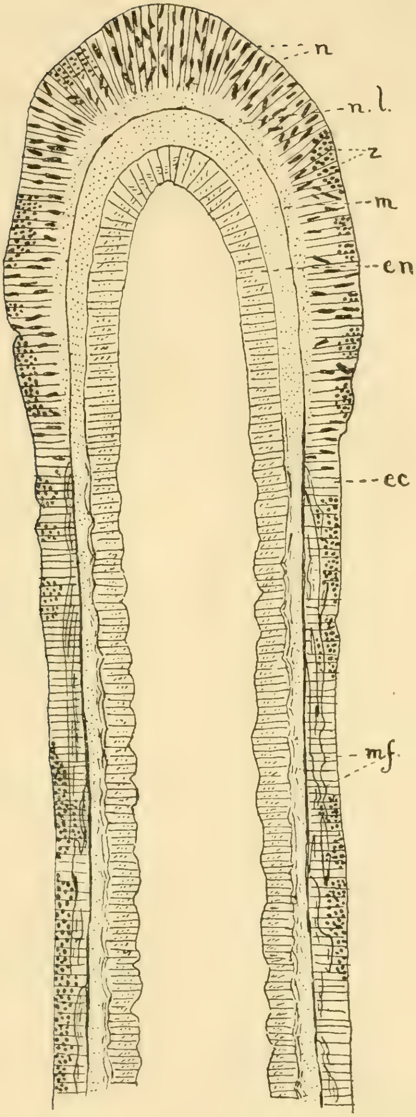

Fig. 3.—Longitudinal section through a tentacle: *ec.* ectoderm, *en.* endoderm, *m* mesoglœa, *m.f.* muscle fibres, *n.* nematocysts, *n.l.* nerve layer, *z.* zooxnathellæ.

zooxanthellæ. There is a definite nerve layer at the base of the ectoderm in the region around the tip where there are numerous nematocysts to control. The mesoglœa is dense, but becomes more fibrillar towards the base, where it also sends out branches which very often divide. Near the base also the nerve layer becomes much thinner.

Septostomes or Mesenterial Stomata.

"In the genus Actinia these stomata are found in the uppermost inner angles of the complete mesenteries close beneath the mouth, and are probably the result of incomplete union of the mesentery with the stomatodæum." This is how they are described by Professor Bourne in (5). They are known as internal stomata. In some other Actiniæ, e.g. *Tealia coriacea* (*crassicornis*) and *Metridium dianthus*, external stomata are present. These are openings situated in the upper third of each mesentery between the longitudinal and the parietal muscles. In *Metridium* septostomes are found on many of the imperfect as well as on the perfect mesenteries, though there are no septostomes on the directive mesenteries. Both internal and external septostomes are present in some anemones, e.g. Hertwig says of the Actinian which he named *Dysactis crassicornis*, "Two kinds of stomata are found on the muscular part of the septa—the peristomial or external stomata are very large, whilst the marginal which lie close to the wall are small." These septostomes are also found in the primitive anemones, e.g. *Halcampa chrysanthellum* possesses external stomata. No septostomes were found in any of the Edwardsidæ. External stomata are present in all the mesenteries of *Eloactis mazeli*, and each takes the form of an elongated slit down the mesentery separating the retractor muscle from the parietal muscle. These stomata provide a means of communication between the radial chambers separating the mesenteries, and probably thus ensure a better method of circulation. Again, undoubtedly they facilitate rapid retraction, for without the septostomes there would be a danger of the mucilage, etc., present in the radial chambers of the cœlenteron getting clogged in the uppermost parts, whereas the presence of the septostomes provides free passage from one chamber to another, not only by way of the axial space into which they all open, but also *via* these stomata.

Systematic Position of Eloactis mazeli.

Delage and Hérouard (6) have temporarily placed this anemone in the 11th family of the Heteractinæ with several other anemones whose internal structure is unknown.

The elongated form of the body, the absence of a definite sphincter muscle, and the presence of a small number of mesenteries, are characters of Eloactis which show that it is related to the primitive, rather than to the more advanced anemones: the latter do not possess an elongated body, but are characterized by the presence of a definite sphincter muscle and a large number of mesenteries. The Edwardsidæ and the Halcampidæ are two of the most primitive families whose members have an elongated body form, no definite sphincter muscle, and a small number of mesenteries. The Edwardsidæ have eight mesenteries, whereas in *E. mazeli* there are twenty; therefore Eloactis cannot be placed with Edwardsia, the sole genus of that family.

The family Halcampidæ has been defined by McMurrich in the paper already referred to (2), as "Actiniæ with a small number of mesenteries, six, ten, or twelve pairs being all present; longitudinal muscle pennons narrow, but strong; no special sphincter muscle; conchula present or absent; base usually rounded and vesicular." In this family, therefore, McMurrich places Halcurias and Peachia as well as the genus Halcampa. Eloactis, with a small number of mesenteries and no sphincter, may be placed in the Halcampidæ. It may be closely compared with *Halcurias pilatus*, as described by McMurrich, and both are found to possess the following characters:—

Column cylindrical; ten pairs of mesenteries, all of which are perfect. There is no special sphincter muscle, and the tentacles are not covered after contraction.

There is one siphonoglyphe, and on the surface of the stomatodæum are numerous ridges.

All the mesenteries bear reproductive organs.

The mesoglœa is fibrillar, especially towards the inner surface.

Halcurias has an adherent base, whereas the members of the Halcampidæ have a rounded and vesicular base. *Eloactis mazeli* and *Eloactis producta* have indications of a slightly adherent base; but in these three forms this character is outweighed by the small number of the mesenteries and the structure of their muscles.

The structure of *E. mazeli* shows that this form is slightly more highly specialized than *Halcurias pilatus*. In the latter, the four pairs of mesenteries situated in the sulco-lateral and lateral intermesenterial spaces are less extensively developed than the other six, and the siphonoglyphe is neither deep nor well defined. On the other hand, *E. mazeli* has all its mesenteries fully developed and has a deep and well-defined siphonoglyphe ; also the distribution of nematocysts is different in the two forms. Eloactis possesses twenty highly specialized tentacles, all well armed with nematocysts, and these are present only on the tentacles, especially on their ovate heads. *H. pilatus* does not possess such highly specialized tentacles ; they are more numerous, and nematocysts are present on the disk and body wall as well as on the tentacles. Thus the tentacles are not so well adapted as feeding and defensive organs, and the division of labour is not so complete as in *E. mazeli.*

Peachia is probably still more advanced :—

It has a single deep siphonoglyphe like *E. mazeli*, but the longitudinal retractors of the perfect mesenteries of Peachia are more elongated (in section), and there is a better developed system of musculature than in *E. mazeli.*

Eloactis mazeli is therefore an elongated anemone, with twenty highly specialized tentacles, ten pairs of perfect and fully-developed mesenteries, and a deep and well-defined siphonoglyphe, and is probably intermediate in position between Halcurias and Peachia.

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Calliobdella lophii, Van Beneden and Hesse.

By

W. Harold Leigh-Sharpe.

On May 12th, 1913, four specimens of the marine leech (*Calliobdella lophii*) were taken by myself whilst working at the Marine Biological Association Laboratory, Plymouth. The leeches were parasitic on the skin of a large angler (*Lophius piscatorius*), just behind the gill covers and in front of the pelvic fins, two on each side. The angler was caught in Jennycliff Bay within a few hundred yards of the shore, about 3.15 p.m., half-ebb, and was taken in a small trawl only just large enough to contain it; shrimps were present in the same catch, but no fish.

Calliobdella was previously unknown at Plymouth. The leech was named by van Beneden and Hesse in 1863 from five specimens found in March by Hesse at Brest.* Some of the external characters alone were described by them. They omit to mention, however, that the genus is characterised by its having six annuli to each body segment, a point which it shares in common with Ichthyobdella and Pontobdella, but which separates it from other genera. They describe so accurately the beautiful appearance of this leech that their own words suffice:—

"An animal carrying a sucker at each extremity of the body, the posterior very large and simple. The body divided into two distinct regions, a neck region bare, and a region of the body properly so called, this latter carrying laterally rounded tubercles on the segments or cutaneous folds."

"This species attains a length of five or six centimetres." (Two of those captured at Plymouth were seven or eight without extreme extension.) "It lives on the angler (fishing-frog), *Lophius piscatorius*. The body is elongated, slightly convex above, flattened below. The skin is tough, with tubercles on the side, and divided into twenty-four segments, of which ten or a dozen belong to the region of the neck, the others to the body properly so called. The neck and the posterior sucker are paler than the rest of the body; the segments of the neck are covered

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* "Recherches sur les Bdellodes ou Hirudinées, 1863."

with minute black dots ; the body is of a clear brownish green, ornamented above with broken, parallel black lines. The body is paler underneath, showing rose-pink markings in the form of a V. It is very noticeable also that the last segment but one of the neck is ornamented with an orange band which encircles it. The movements of this leech are very lively."

They were very lively in captivity, clinging firmly with the posterior sucker to the jar containing them, and seeking eagerly for some fresh host with the anterior end.

They moved occasionally with the usual loop-like movements of a leech, taking great care to place the posterior sucker as exactly as possible in the position previously occupied by the anterior.

Calliobdella is sharply divided by a constriction into a neck and a body. Blanchard,* who mentions this leech as occurring in the Mediterranean, states that the segments of the body are formed of three to six annuli according as the three primordial rings are more or less divided by chorisis. All those in my possession have six annuli to the segment. The same author suggests that the animal is flattened when young and rounded when old. Further, he alters the name for orthographical reasons to Callobdella.

On the body, but not on the neck, are lateral protuberances, *eleven* pairs of hemispherical projections on each side of the animal, "rising and falling as if by respiration," as Dalyell† said of a leech he described as "Hirudo vittata," and which possibly was the same. These are rudimentary branchiæ, corresponding to the large external branchiæ of Branchellion, and similar to those of the North American and European marine and fresh-water form, Cystibranchus.

According to Quatrefages‡ these appendages do not receive the blood contained in the vessels, but only the lymph which becomes diffused, and which makes the respiration truly lymphatic.

Ichthyobdella is without these tubercles, and Pontobdella, which is further distinguished by its warty appearance also. Owing to the six annuli of the segment being formed by chorisis from three, the first respiratory vesicle is on the first double ring, the second on the fourth double ring, and so on. The anterior half of each double ring carrying the vesicle is spotted.

There are no eyes.

The extreme size of the posterior sucker in *C. lophii*, it being more than twice the maximum breadth of the body, distinguishes this species from the other (or others). Ludwig Johannson,* who describes this leech as rare, admits that he has never seen one alive, and states that the one in the museum at Stockholm was taken at Bergen in 1879, also that it occurs on the coast of Norway, and the two specimens he dissected were sent by a fisherman from Helsö in S. Bohuslän. He, adopting the altered name Callobdella, characterizes the genus by its possessing a large copulatory organ with a bursa and two seminal vesicles, while in other genera the copulatory organ is without the latter.

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* "Hirudinées de l'Italie, Boll. Mus. Zool. Torino," Vol. IX, 1894, No. 192.

† "Powers of the Creator." Dalyell. Vol. II, p. 9, 1858.

‡ Ann. Sc. Nat., Vol. XVIII, p. 322, 1852.

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* Johannson. "Die Icthyobdelliden in Zool. Reichmuseum in Stockholm, 1896."

Habit and Habitat in the Galatheidea: a study in adaptation.

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With Figure 1 and Plates 1–4 in the Text.

THE heterogeneous assembly of Decapod Crustacean types classed as "Anomura" is well known to present a wide range of variation in structural features; in fact, the most apparent bond of union between its highly dissimilar sub-groups consists in the still greater disparity which exists between these and members of either "Macrura" or "Brachyura" proper. The Anomura may best be compared with that other heterogeneous group, the Amphibia: each, apparently of aquatic ancestry, has suffered in the unequal contest with a highly specialized offset from the parent-stock (Brachyura-Reptilia); the survivors of both the ill-fated groups, Anomura and Amphibia, are few in number, varied in type, and probably not closely related among themselves.

Among the Anomura, the sub-group Galatheidea present a fairly connected natural assemblage of types. Study of this sub-group reveals the presence of two distinct and widely divergent lines of specialization—on the one hand, for life on shore (near or above low-tide mark), and, on the other, for life in deeper waters. Thus the group comprises, together with more or less intermediate forms, three well-marked types:

A. THE *Galathea squamifera* TYPE.

The characteristic species frequents the fairly open seas which surround our coasts, and is rarely found near low-tide mark except for a short time in spring; the form of body is almost Macrurous, and the abdomen, though usually flexed, is relatively large, and of no little importance in swimming.

B. THE *Porcellana platycheles* TYPE.

The characteristic species lives well up in the muddier portion of the intertidal zone, and is common about midway between high and low tide marks. The form of body presents many peculiarities, both superficial and in detail, comparable with those which are regarded as characteristic of the Brachyura, furnishing an excellent example of "convergence." . . . The abdomen is greatly reduced in size, the length of the carapace scarcely exceeds its breadth, and the habit of clinging to stones is developed to a marked degree.

C. The *Munida rugosa* type.

Characteristic of fairly deep waters (found at depths varying from 10 to 600 fathoms). The general form of body closely resembles that of type A, but obvious specializations for deep-sea life exist.

Thus, within the group Galatheidea, a few species (those of group C) have been driven by stress of competition in the shallower waters to seek shelter in the deeper and more sparsely populated regions of the sea; but the main line of specialization in the group is in the direction A to B —towards adaptation for life higher up the shore. It is the aim of this memoir, by describing details of the structure of the branchial and other organs of the Galatheidea, to show what peculiarities have arisen in connection with the need for special precautions :

(*a*) For ensuring steadiness of balance when the animal is in progression or at rest within the wave-washed region of the shore;

(*b*) For guarding against the choking of the branchial cavity and clogging of the branchial organs by the mud of the low shore.

In doing this, an endeavour is made to arrange these details in logical and progressive order, as indicating for the more crab-like members of the group "the base degrees whereby they did ascend."

I. MODIFICATIONS WHICH PROMOTE EFFICIENCY IN RESISTANCE TO WAVE-WASH AND IN PROGRESSION ON THE SHORE.

It is convenient to use the type-species A (*Galathea squamifera*) as a starting-point from which to trace various lines of specialization within the group, this species being probably among the nearest to the Macrurous ancestor. We find throughout the genus Galathea few specializations of a definitely Anomurous character: the long, rather narrow carapace and powerful abdominal swimming "tail" with broad tail-fan obviously mark the active swimmer. In those members of the group which frequent the higher coast-zones—notably the Porcellanids—and which thus assume the creeping rather than the swimming habit, we note a reduction in importance of the Macrurous characters—a diminution in size of the abdomen, accompanied by a broadening of the carapace and strengthening of the ambulatory thoracic appendages. The reduction of the abdomen is well marked in *Porcellana platycheles*, which, as a general rule, does not swim, but moves from place to place in a crab-like sidling fashion. The abdomen, which is habitually carried tucked-up beneath the thorax, is relatively very weak, and narrowly triangular in outline, and the tail-fan, though still present, is reduced in size. The abdomen is rarely unfolded except under special circumstances, as when the animal is upset on to its back. In this case, the abdomen is flapped vigorously, so as to raise the animal in the water and alter the inclination of the body, allowing it to fall back into the natural position, while the chelæ are extended to catch at any means of support to which it may be possible to cling. A similar action of the abdomen has been observed in Cancer and Carcinus individuals, when subjected to similar conditions, but in these two Brachyuran genera the absence of the tail-fan renders the flapping less effective; this deficiency, however, is not of much consequence, as their superiority in weight and strength gives Cancer and Carcinus a greater stability than is possessed by Porcellana.

Decapoda which frequent the shore have the carapace much broader and flatter than in Macrura, and this has led to the sharp lateral folding of the carapace, giving protection to the branchial organs; this broadening is also of importance in connection with the above-mentioned habit of sideway progression, as we generally find the long axis of any body is turned in the direction of habitual movement. This method of advance in another than the forward direction is peculiarly suited to animals endowed with the Decapod Crustacean's type of sense-organs and frequenting obstructed places, and also to those whose walking limbs are spread in the almost radial fashion characteristic of the Porcellanids. The efficient clinging mechanism so afforded is based on the principle which determines the radial spreading of tent-pegs with their ropes, and of the several hooks of a grapnel, and has doubtless been developed in connection with the habit (already marked in Galathea, and most pronounced in *Porcellana platycheles*) of clinging to the under-surfaces of stones, and thus resisting the force of wave-wash as well as that of enemies. The radial arrangement of the limbs also endows the animal with facility of movement in an oblique, as well as in the directly transverse, direction—a valuable asset to a dweller in the intertidal zone of shifting pebbles.

In connection with the strengthening of the thoracic limbs of *Porcellana platycheles*, we note in this species the greatest concentration of the thoracic nerve-ganglia observed in any of the Galatheidea, the condition almost approaching that which characterizes the Brachyura (see Plate 1, Figs. A, B, C, D, E). The last thoracic leg (appendage XIII), which in the Galatheidea is modified into a slender cleaning-organ, of course does not participate in the clinging action or in locomotion, and it is noticeable that, even in *Porcellana platycheles*, the ganglion of the 13th segment remains semi-isolated from the central mass formed by the fusion of most of the other thoracic ganglia.

The marked clinging-habit of *Porcellana platycheles* should be connected not only with the resistance to dislodging forces, but also with the general protective "melting into the background." The body is flattened, and when at rest is pressed closely against the rock—the chelæ are flattened and expanded in the horizontal plane, and are notched so as to fit accurately against the front edge of the carapace—and the whole dorsal body surface is coated with shaggy, grey, insensitive hairs, nearly matching in colour the rock to which the animal clings (see Plate 2, D). In this connection we remark also the absence of those transverse ridges of the carapace which are so conspicuous in more active members of the group. These carapace ridges in Galathea are fringed with hairs of a fairly simple, once-pinnate type (Plate 2, A, and Plate 4, B), whose continual agitation by the motion of the surrounding water probably prevents the settlement of such unwelcome guests as Hydrozoa, Polyzoa, etc., likely to retard the swimmer by increasing the friction-surface. A sedentary form like *Porcellana platycheles* has no such interest in avoiding encrustation—and in it we find no trace of ridges or of waving hairs, the shaggy hairs of the dorsal surface being too close and coarse to be easily agitated by movement of the water. Again, the ridges, if present, would inevitably detract from the general protective resemblance to surroundings, and from this standpoint it seems likely that the presence of encrusting organisms may be of positive advantage to the crab. At all events, Spirorbis is quite commonly found attached especially to the chelæ of *P. platycheles*—a position likely to ensure commensalism (Plate 2, D).

II. MODIFICATIONS WHICH TEND TO PREVENT CHOKING BY MUD.

A Macrurous form such as we suppose the Galatheid ancestor to have been, swimming in the clearer open water, required, and probably possessed, no special devices for protection of the branchial cavity from stoppage: we find in the Lobster, Penæus, etc., a notable absence of such protective devices. Here, the gills are just sufficiently well guarded against dangers of friction, etc., by the lateral branchiostegite flap of the carapace, which loosely overhangs the cavity. The case of the Brachyura is quite otherwise. These shore-living Crustacea are constantly exposed to the dangers of life in the wave-washed zone, and protection against one of the greatest of these dangers is ensured by the enclosing of the branchial cavity by the strongly-curved branchiostegite. This leaves only the following apertures : a pair at the posterior end of the carapace, a pair at the bases of the chelæ, a pair near the mouth—and, on each side, a long chink, so narrow as to be practically inconsiderable, between carapace and thoracic leg-bases. The first two pairs of apertures (entrance channels for the breathing current) are well guarded by a straining apparatus formed by a fringe of hairs of very complex structure (Plate 4, G), while the aperture on each side of the mouth (an exit channel) can be protected by the folding of the plate-like maxillipedes against the body-wall. The fourth pair of apertures, mere chinks, are curtained by a fringe of hairs bordering the branchiostegite and by the tufts of "coxopoditic setæ."

One might expect to find in Galatheidæ a type of arrangement more or less intermediate between these two extremes—the Macrurous and the Brachyurous—and such is, in fact, revealed. Throughout the group, the closing-in of the branchial cavity is far less complete than in the Brachyura, although a curved and down-bent branchiostegite protects it laterally, and the paired inhalent aperture (posterior, near the bases of appendages XII and XIII) is guarded by a ring of hairs. Coxopoditic tufts also prevent the entrance of mud through the longitudinal crack between branchiostegite and leg-bases—which crack is far wider than in Brachyura, the whole branchial cavity being wide in the vertical rather than in the horizontal plane.

Galathea, an active swimmer, has retained some of the epipodites so characteristic of primitive Macrurous forms like Penæus. In *G. squamifera* (common around our coasts), there are epipodites, fringed with long and fairly simple hairs, on appendages VIII to XI (Plate 2, B, and Plate 1, F). One important function of the epipodites, as established by M. Bohn ("Des mécanismes respiratoires chez les Crustacés Décapodes," *Bull. Sci. Fr. et Belg.*, XXXVI) is to brush the surfaces of the Arthrobranch gills and sweep them clear of particles. With so efficient a sweeping mechanism, it seems that elaborate precautions against the entrance of mud are unnecessary : we find that in this species the guardian-hairs which fringe the inhalent aperture are of the same fairly simple type as those which occur along the whole of the carapace edge (Plate 7, B).

This absence of high specialization along this particular line should be correlated with the habitat of the species, which visits the muddiest part of the shore (just below low-tide mark) only for a very short time in spring. The allied species, *Galathea strigosa*, shows increased complexity of structure of the hairs which guard the inhalent aperture and fringe the branchiostegite. We connect the advance in specialization with the fact, noted by M. Bohn (*op. cit.*), that " in *G. strigosa*, considerable movements of the carapace supplement the action of the scaphognathite." This carapace-flapping would doubtless expose any epipodites present on appendages IX to XI to the danger of being bruised and torn—at all events, the epipodites of these segments are wanting. This reduction of sweeping mechanism within doubles the need for a guard at the entrance portals, which need is satisfied by the increased complexity of straining-hairs described above. Thus, in *G. strigosa*, feebleness of the scaphognathite has induced flapping of the carapace—this being in its turn connected with reduction in the number of epipodites and correlated complexity of straining hairs (see Plate 2, B, and Plate 4, F). It is interesting to note that in this species the epipodite of appendage VIII has alone survived, and this perhaps owing to its position opposite the blunt angle of the branchiostegite, where in all probability friction is not great.

Galathea intermedia, like *G. strigosa*, has suffered reduction in the number of its epipodites (though we are as yet unable to guess at the biological significance of this reduction) ; here, only epipodites VIII and IX remain, and here again correlated specialization of the straining-hairs is observed (Plate 4, E).

Two deep-water species of Galatheidea—*G. nexa* (to 70 fathoms) and *Munida subrugosa* (to 600 fathoms)—while resembling *G. squamifera* in their possession of the full number of epipodites (series VIII to XI), yet afford a parallel with the case of *G. strigosa* and *G. intermedia* in the relatively complex structure of the straining-hairs. This apparent anomaly seems to point to a need for special precaution against choking of the branchial passage in these two deep-water species ; this is one item of a lengthy list of peculiarities which characterize the branchial apparatus of deep-sea members of widely dissociated groups (compare the peculiarities of the branchial organs of the Lepetidæ among Prosobranch Gasteropods, etc. etc.).

A striking feature of such shore-living types as Porcellana is the complete loss of the epipodites of appendages VIII to XI. This reduction should perhaps be correlated with the marked development of the clinging habit and the radial working of the legs, which entail movements likely to endanger organs occupying the position of epipodites. We should probably connect with this habit of spreading the legs radially (a habit which prevails throughout the Galatheidea, though it is most marked in Porcellana) the peculiarities of the general gill-formula of the group, which is characterized by the absence of podobranchs and importance of the pleurobranchs. Some of the leg movements involved would seem to be a source of danger to gills in the position of podobranchs (near the outer edge of the branchial chamber), exposing them to a risk of friction against one another and against the edge of the branchiostegite. Reduction of the organs exposed to this danger is accompanied by increased importance of the gills of the two inner series (arthrobranchs and pleurobranchs). (See Plate 1, F and G.)

In connection with the ascent of the shore by Porcellanidæ, the alteration in shape of the branchial cavity is noticeable, the shape of the cavity being practically of a type intermediate between those found in the swimming Galathea and the established (unrelated) shore-form, Cancer.

Porcellana platycheles, a sluggish species inhabiting the muddiest part of the mud-zone, shows a marked degree of specialization of the hairs which guard the inhalent aperture. These hairs, as well as those of the coxopoditic tufts, are of a much-branched and twice-pinnate type, and *exactly* resemble those which, in members of the Brachyura, constitute so effective a strainer, being totally dissimilar to the corresponding structures in Galathea (any species). (Plate 4, G.)

It is remarkable that *P. longicornis*, unlike *platycheles*, has none of this complicated structure: all the hairs near openings of the branchial cavity are alike of the simple type characteristic of *Galathea squamifera* (Plate 4, B).

It is necessary to bear in mind the difference in habitat of the two species, *P. platycheles* being a typical mud-dweller, whilst *longicornis* frequents such shores as those of Guernsey, where igneous rocks weather into reefs separated by steep gullies, swept perfectly clear of mud by the tidal currents.

With specializations which tend to promote efficiency of the breathing current we must class a peculiar growth of hairs found on the basal joint of the third maxillipede of all species so far examined. These hairs are short and strong, furnished with short, jagged saw-teeth, and are matted together to form a kind of felt-work across the gap between the maxillipedes of the two sides. This acts as a forward extension of the floor of the branchial cavity, and seems to guard against the entrance of water from below, which might meet and check the outgoing current (see Plate 4 and Text Figure 1).

Various members of the group show an interesting series of devices ensuring steadiness of the breathing current—such devices being particularly necessary in animals with the enclosed type of branchial cavity. Prof. Pearson, in his *Cancer* Memoir (L.M.B.C.), has pointed out the existence in that part of the carapace which floors the branchial cavity of a ridge, which by its presence helps to maintain a steady current of water past the gills. Specializations of an apparently somewhat similar function are visible in certain of the Galatheidea. The branchial cavity of Galathea and of Munida is long and narrow, with a slight spiral twist, and is floored (unlike those of Brachyura) by the body-wall itself: we trace in this floor the line of a definite, though not prominent, longitudinal ridge external to a groove along which the main body of the breathing current appears to flow (Plate 3, A, i and ii).

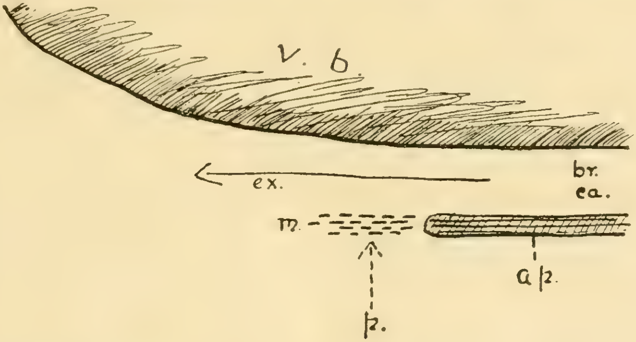


Fig. 1.—Diagram-Longitudinal section through the front end of the body of one of the Galatheidea.
v.b. = ventral body-wall.
ap. = branchiostegite of one side.
br.ca. = branchial cavity of that side.
ex. = direction of ex-current stream.
p. = line of a theoretical in-current.
m. = position of matted hairs on the maxillipede bases, which prevent the entrance of the current p.

Porcellana has a corresponding specialization more nearly of the Cancer type: the branchial cavity is partially floored (i.e. towards its front end) by a special portion of the edge of the branchiostegite, which is peculiarly twisted to produce a ridge doubtless similar in function to the rather more definite ridge of Cancer (Plate 3, B, and Plate 1, G).

Porcellana shows a remarkable respiratory habit—that of temporary suspension of the breathing activities on alternate sides of the body.

The flagellum of one of the maxillipedes (probably of the 2nd) is obviously of use in strengthening and accelerating the ex-current stream, and its motion or stillness forms a good guide to the progress of the breathing activities on either side of the body, in addition to the indication furnished by the motion of particles in the water. It was noticed that both *P. longicornis* and *P. platycheles*, when at rest, almost invariably hold the chela of one side (α) further away from the body than its fellow (β) : subsequent observation, many times confirmed, revealed the fact that *only* from the exhalent aperture of the α side did an ex-current stream proceed : apparently *no* respiratory stream was passing through the branchial cavity of the β side, and certainly the flagellum of that side was at rest. Supposing that the chela of the *left* side is held away from the body : only the *left* flagellum is meanwhile at work, a strong ex-current stream proceeds from the *left* side only, and the antennules, at their water-testing work, are constantly directed towards the *right* side of the animal (Plate 2, C and D). Meanwhile, on the *right* side of the body issues *no* ex-current stream, but generally the *right* antenna is kept in fairly constant motion, being swept from front to back, and vice versa. In other words, there is apparent suspension of the respiratory function of the right side of the body, compensated by the redoubled activity of the sensory function of the same side. In a normal captive Porcellana, the duration of this period of suspension is usually about half an hour ; at the end of that time the animal becomes restless, "fidgets," and ends by reversing the functions of the two sides of the body, after a brief period of irregular movement of first one flagellum, then the other, and occasionally even of both at once. It must be noticed that in Porcellana there is *no reversal of the current* such as M. Bohn observes (*C.R. Ac. Sci.*, CXXV, 1897, p. 441, "Sur le renversement du courant respiratoire chez les Décapodes") in Carcinus, etc., and which may serve to rest the muscles of the scaphognathite or to cleanse the branchial cavity. Probably this resting of the muscles is at least as well ensured by the alternate working of the organs of the two sides. M. Bohn remarks that, in animals which have the reversal habit, the number of reversals within a given time may be increased by placing the animal in a toxic solution such as extract of Red Seaweed. Similar experiments performed on Porcellana produced *no* reversal of the current, but had the effect of causing the alternations in function of the two sides to become rapid and irregular. Galathea exhibits no such alternation, and on placing it in Red Seaweed extract there was detected distinct reversal of the respiratory stream, although the backward current produced was but feeble and irregular. The result of the experiments performed on Porcellana is surely to show that any recuperative purpose effected by the reversal of the respiratory stream in the Decapods for which such reversal has been proved is fulfilled in Porcellana by the alternate resting and working of the two sides.

Throughout the Galatheid group we note a praiseworthy striving after cleanliness on the part of its members, which must of course be referred to the habitat of these animals. Apart from the absolute necessity for keeping a clear channel through the branchial cavity, it is of distinct advantage to prevent mud particles from collecting among the hairs of the coxopoditic tufts and near the openings of the branchial cavity itself, and it is clearly the function of the curiously modified thirteenth (last thoracic) appendage to clean and brush these hairs, as well as the back of the carapace. Galathea and Munida especially have need of precaution against the settling of foreign particles in the transverse grooves of the carapace. The ultimate segment of the thirteenth appendage in Galathea, Munida, and Porcellana, bears hairs which by their structure are peculiarly well fitted for this work of cleaning out chinks and crannies (Plate 4, K), each hair being bent into a kind of sickle-shaped hook, fringed on its inner side with short, pointed teeth, and doubtless constituting a most effective scraper. In one species of Porcellana (*P. platycheles*, see Plate 7, K, ii), these hairs appear to have suffered degeneration from some unexplained cause (perhaps in connection with the absence of carapace ridges), growing less strongly curved and with blunt teeth. It is noticeable that members of the genus Porcellana (without epipodites) frequently thrust this appendage XIII inside the branchial cavity itself, doubtless to clean it—a course of proceeding which Galathea (furnished with epipodites) apparently does not follow.

The antennules (water-testing organs) and the antennæ (which are still important tactile organs in the Galatheidæ) must, if they are to retain their sensory function, be kept scrupulously clean, and their cleansing, which frequently takes place, is a process to delight the observer. These appendages are bent sharply downward, then the endopodites of the third maxillipedes are unfolded, and antennules and antennæ are drawn slowly upwards in such a manner as to be thoroughly well combed by the long hairs of these palps, which hairs have the form of strong double-edged saws or combs (Plate 4, I, i). These endopodites of the third maxillipedes, by the way, exhibit an interesting series of specializations throughout the group. Their main functions are (*a*) to gather in small particles of food to the mouth by a sweeping movement; (*b*) to comb the hairs of antennæ and antennules; and (*c*) to guard, when folded, the exit channels of the branchial cavity. In Galathea and Munida, the joints of the endopodite are long and thin, and the whole maxillipede approaches in form the type of the primitive Arthropod appendage, save that the endopodite is slightly flattened, and can, when folded, form a fairly plate-like structure. *P. platycheles* shows greater specialization of the endopodite, the joints being very much flattened and broadened, although the span of the limb when straightened is considerable. *P. longicornis* is in this respect almost intermediate between the two types (Plate 6, A, B). All these species have specialized hairs of two kinds on the ultimate and penultimate segments of the endopodite. These are—(*a*) *sweeping hairs* (Plate 4, C), very long and slender, bearing two regular rows of fine branches; and (*b*) *combing hairs* (Plate 4, I, i), not so long as the former, but stouter, and bearing two rows of very stiff points like the teeth of a double comb.

Comparison with the third maxillipede of Cancer and allied Brachyura is instructive. In Cancer, the broadening and flattening of the proximal portion of the endopodite and the reduction of its distal joints have proceeded far (see Plate 3, D, E, F). The function of the endopodite here is perhaps exclusively to protect the exit channel, and it is converted into an organ primarily plate-like and protective, and destitute of sweeping hairs. In connection with the life high up the shore, antennæ and antennules are reduced in size and importance (experiments prove the former to be practically insensitive to touch), so that this double reduction renders the combing of antennæ and antennules by the hairs of VIII impracticable. The combing hairs, having lost their function, are obviously degenerate: though they retain their two rows of lateral branches, these branches are so much thickened as to be almost fused in rows, and quite disqualified as combing teeth. The fact that Algal growth has been found attached to the antennæ of practically every specimen of *Cancer pagurus* examined appears to prove conclusively the absence of combing device and sensitivity. Carcinus (a more active Brachyuran than Cancer, and one proved by experiment to have greater power of antennal perception), has the third maxillipede just long enough to clean the antenna tip, and it is noticed that in members of this genus the combing hairs have persisted without degeneration—also Algal growth is less commonly present on the antenna, and *never* present near the tip. On the other hand, *P. platycheles* presents, in this matter of the combing hairs, a condition markedly analogous with that of Cancer. This must be connected with the general crab-like habit and sluggish nature of the species (compare the settlement of Spirorbis, etc., on the carapace and chelæ).

In this last instance, then, *P. platycheles* exhibits a type of specialization markedly analogous with that of the true crabs, and the species once more asserts its right to be placed among the upper branches of our tree of Galatheid ascent.

EXPLANATION OF PLATES.

Plate 1.

A.–E: Thoracic nervous systems of Decapod Crustaceans.
  A. Of *Astacus fluviatilis* (after Huxley).
  B. Of *Galathea squamifera* }
  C. Of *Munida rugosa* } members of the Galatheidea.
  D. Of *Porcellana platycheles* }
  E. Of *Cancer pagurus*.
    Gn. 1. =supra-œsophageal mass.
    C. œ. =circum-œsophageal ring.
    S. œ. =sub-œsophageal ganglion.
    S. n. =gap for sternal artery.
    Gn. 4, 5–8. =last 5 thoracic ganglia.
    Gn. 8. =ganglion of segment XIII.
    Vn. =ventral nerve-mass.
F and G. Branchial cavity of right side, showing bases of thoracic legs.
    A. Of *G. squamifera*.
    B. Of *P. platycheles*.
      Pl. X to XIII=Pleurobranchia.
      Ep. VIII to XI=Epipodites.

Plate 2.

A. Side view of carapace of *Galathea strigosa*.
    Ep. VIII=epipodite of the 3rd maxillipede (usually turned into the branchial cavity).
B. An epipodite of *G. squamifera*, showing sweeping hairs.
    Ms.=muscle.
D. *P. platycheles*, dorsal view. The flagellum of the *left* side is at work. (N.B.—In this specimen, the chela of the right side is the larger. The illustration by no means does justice to the general shagginess of the species.)

C. Enlarged view (diagrammatic) of a portion of the above.

a. =antennules.
m. =plate-like endopodite of VIII.
fl. =flagellum at work.
ex. =ex-current stream.
S. =Spirorbis tube on chela.

Plate 3.

A. Side view of branchial cavity of *G. squamifera*, gills removed (diagrammatic).

c. =cut edge of body-wall, etc.
In. =inhalent aperture.
Ex. =exhalent aperture.
Gr. =position of groove.
r. =line of a not prominent ridge.

A ii, B i and ii, and C i=diagrams of various branchial cavities in T.S.

A ii. Of *G. squamifera.*
B. Of *P. platycheles* (i, near front end ; ii, further back).
C i. Of *C. pagurus.*
B iii. =Branchiostegite of *P. platycheles,* inner surface.
C ii. =Branchial cavity of Cancer exposed.

r. =ridge.
br. =branchiostegite.
c. =cut edge of carapace.

D.=3rd maxillipede of *G. squamifera* (right side).
E.= ,, ,, ,, *P. platycheles* ,,
F.= ,, ,, ,, *C. pagurus* ,,

en.=endopodite.
ex.=exopodite.

G. =Antenna of *C. pagurus,* with Algal growth.

Plate 4.

Drawings of single hairs (much enlarged).

A. Simple hair, e.g. " shaggy hairs " of *P. platycheles.*

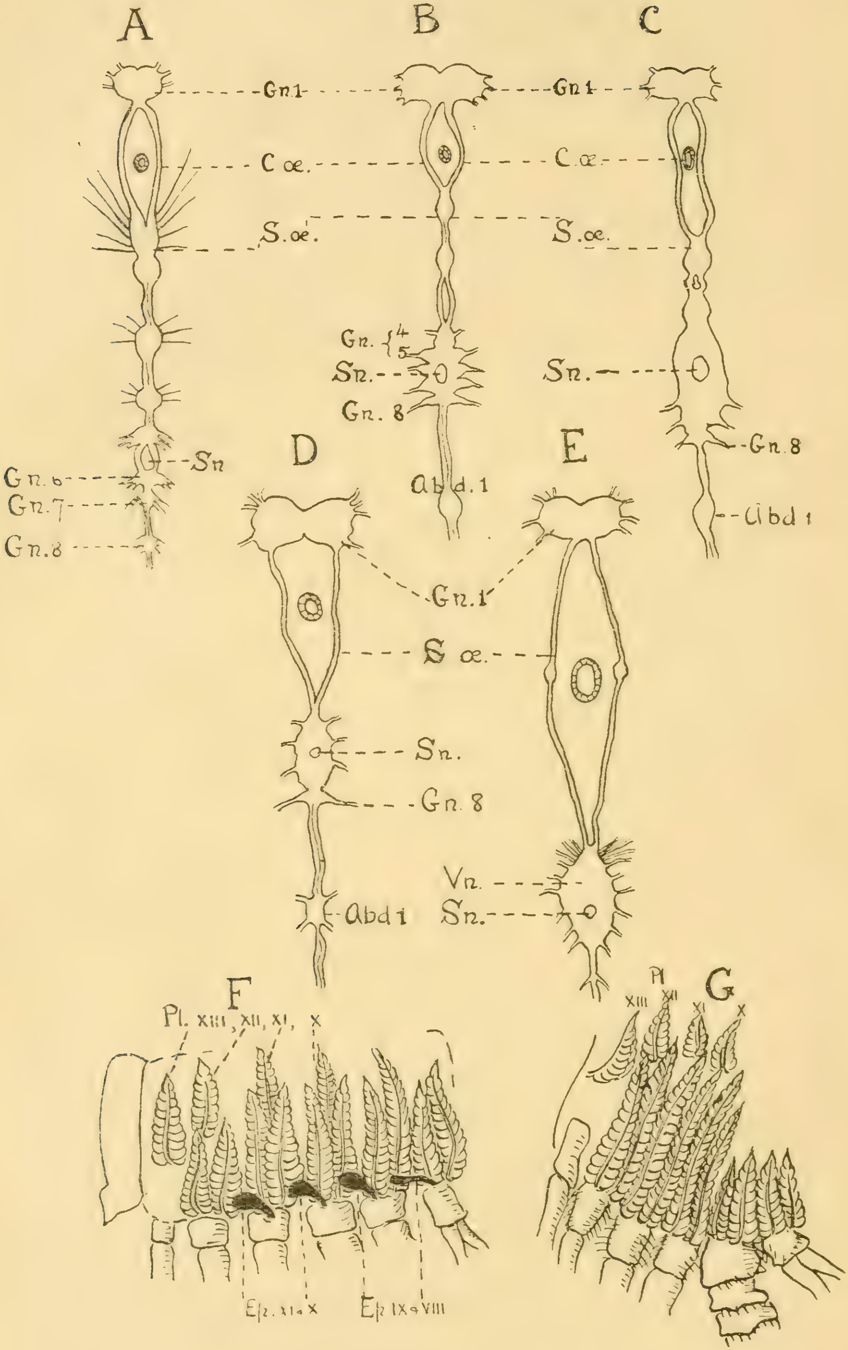
B. Once-pinnate hair, on carapace ridges of Galathea, also fringing the branchiostegite in *G. squamifera.*

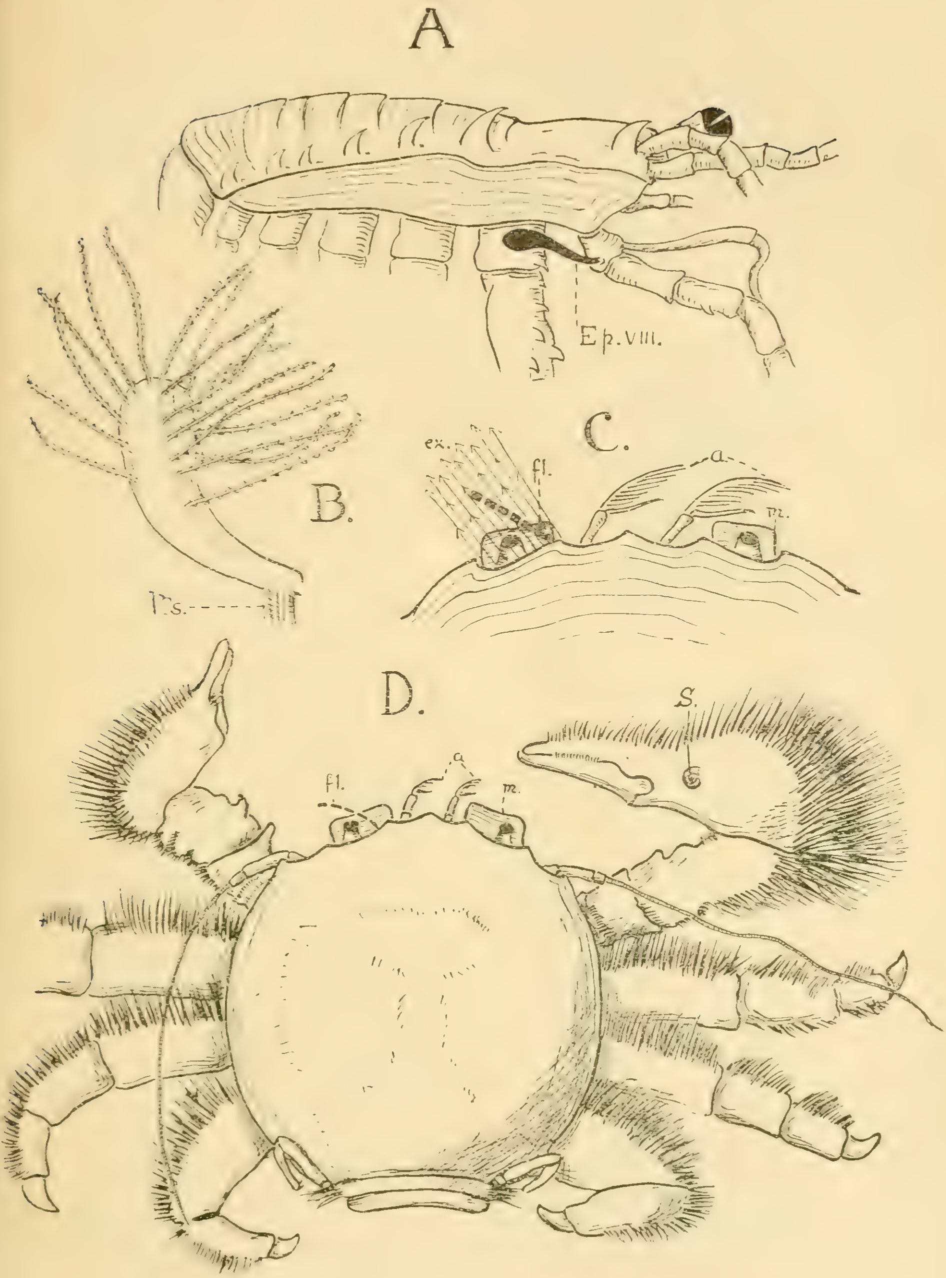
C. In-sweeping hair, on last two joints of endopodite of 3rd maxillipede in Galatheidea.

D. Epipodite hair.

E. Filter hair, fringing branchiostegite, etc., in *G. intermedia, G. nexa,* and *Munida subrugosa.*

F. Strigosa hair, fringing branchiostegite, etc., in *G. strigosa*.
G. Tree-like filter hairs, fringing branchial apertures of *P. platycheles* and Cancer, etc.
  i. Cluster, with collected mud.
  ii. Tip of one hair, more highly magnified.
H. Matted hairs, inner side of basal joint of 3rd maxillipede in Galatheidea.
I i. Combing hair, last two joints of VIII in Galathea, Munida, *P. longicornis*, and *Carcinus mœnas*.
  ii. Degenerate combing hair, *P. platycheles* and *C. pagurus*.
K i. Sickle hair, ultimate joint of XIII in Galatheidea (except *P. platycheles*).
  ii. Degenerate sickle hair (*P. platycheles*).


A
B
C
Gn 1
Gn 1
C œ.
C œ.
S. œ.
S. œ.
Sn
Gn. 6
Gn. 7
Gn. 8
Gn. {4 5
Sn.
Gn. 8
Sn.
Gn. 8
Abd. 1
Abd 1
D
E
Gn. 1
S œ.
Sn.
Gn. 8
Vn.
Sn.
Abd 1
F
Pl. XIII, XII, XI, X
Ep. XI & X
Ep. IX & VIII
G
Pl
XIII
XII
XI
X


A
Ep. VIII.
B.
Ps.
C.
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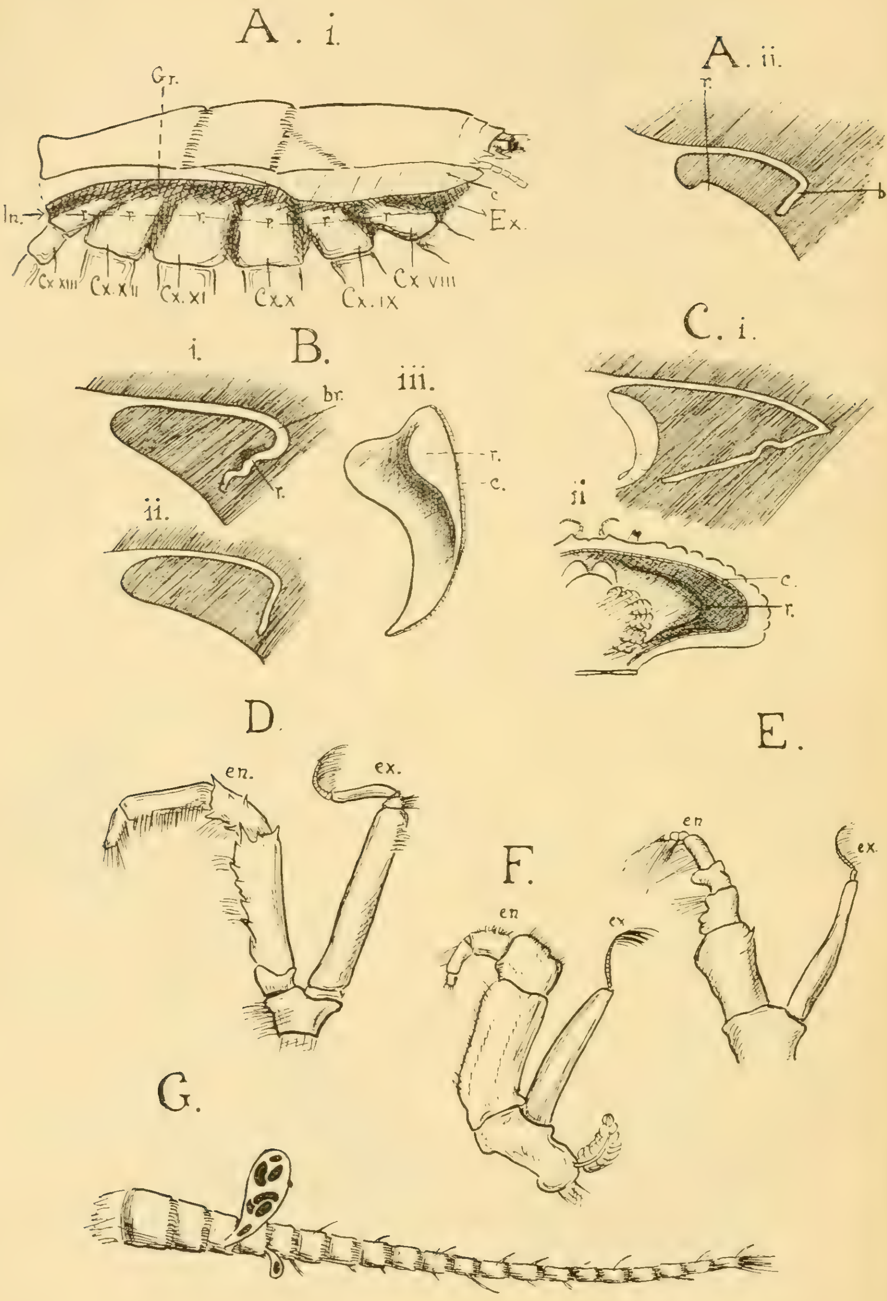
fl.
a.
m.
D.
S.
fl.
a
m.

Plate III


A. i.
Gr.
In.
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c
Ex.
Cx XIII
Cx. XII
Cx. XI
Cx. X
Cx. IX
Cx VIII
A. ii.
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br.
B.
i.
br.
r.
ii.
iii.
r.
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ex
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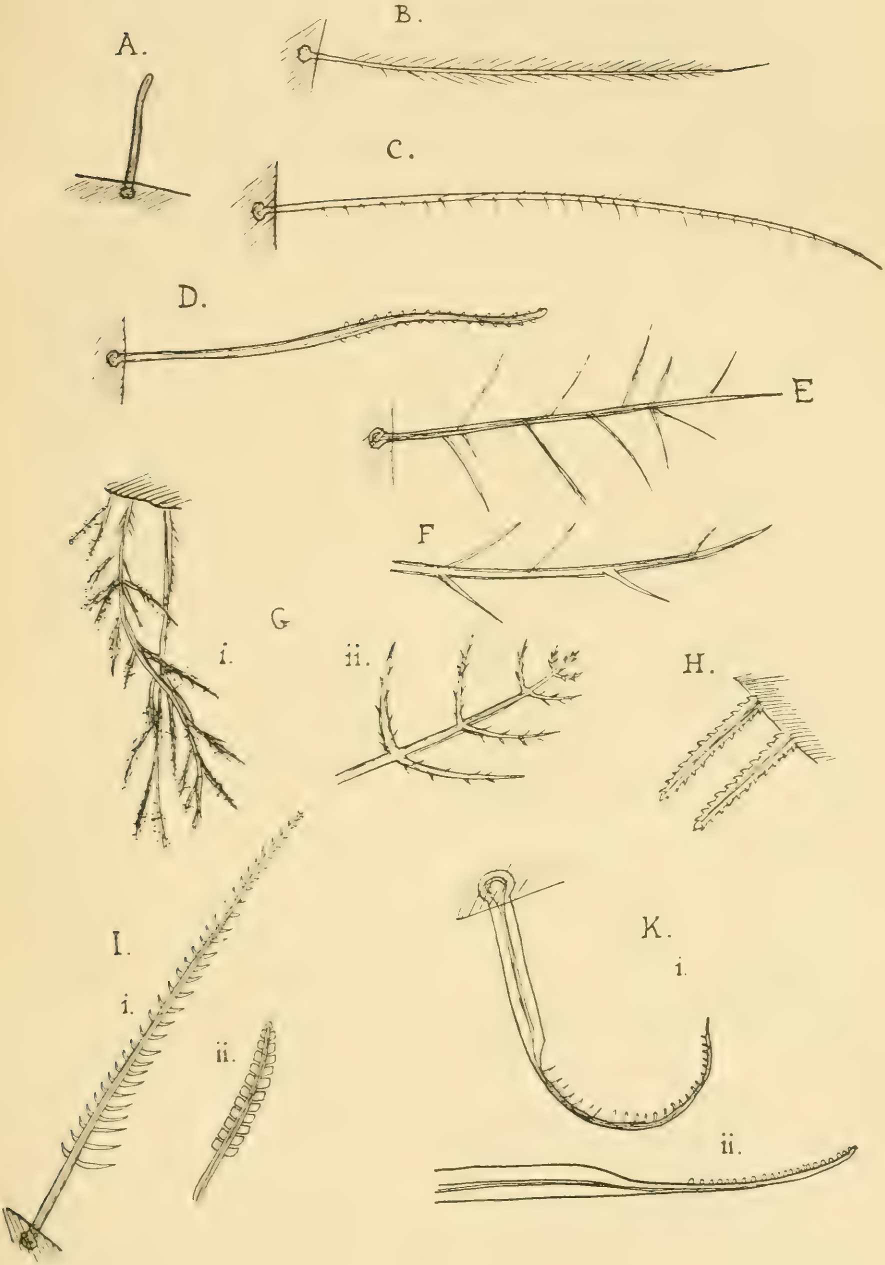
A.
B.
C.
D.
E
F
G
i.
ii.
H.
I.
i.
ii.
K.
i.
ii.

The Shore Fauna of Cardigan Bay.

By

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Cardigan Bay occupies a considerable portion of the west coast of Wales. It is bounded on the north by the southern shores of Carnarvonshire ; its central portion comprises the entire coast-lines of Merioneth and Cardigan, and its southern limit is the north coast of Pembrokeshire. The total length of coast-line between Braich-y-pwll in Carnarvon, and Strumble Head in Pembrokeshire, is about 140 miles, and in addition there are considerable estuarine areas. The entire Bay is shallow ; for the most part four to ten fathoms inshore, and ten to sixteen about the centre. It is considered probable that the Bay was temporarily transformed into low-lying land by accumulations of boulder clay during the Ice Age. Wave action has subsequently completed the erosive removal of that land area, with the exception of a few patches on the present coast-line and certain causeways or sarns. Portions of the sea-floor probably still retain some remains of this drift, and owing to the shallowness, tidal currents and wave disturbance speedily cause the waters of the Bay to become opaque. The prevailing winds are, as usual, south-westerly, and heavy surf is frequent about the central shore-line. This surf action is accentuated by the large amount of shingle derived from the boulder clay. The action of the prevailing winds and set of drifts in the Bay results in the constant movement northwards along the shores of a very considerable quantity of this residual drift material. Where checked by shore contour or river current this drift accumulates to form storm-beaches, which have eventually deflected certain rivers and streams to the northward, as in the case of the Ystwyth at Aberystwyth, the Clarach stream a little further to the north, and the Leri at Borth. Other large accumulations have assisted in the raising of the sarns or "causeways," extensive shallow regions, several of which run out in its northern half into the Bay for a considerable distance. One of these, the Sarn Badrig, dries at low-water spring-tides, nearly 14 miles from land.

Large amounts of muddy fresh water are poured into Cardigan Bay by the numerous torrential rivers and streams which flow from the mountain regions where the rainfall is heavy. Some of these (from N. to S.) are the Soch, Rhyd-hir, Erch, Wen, Glaslyn, Dwyryd, Artro, Mawddach, Dysynni, Dyfi (with subsidiary streams Einon, Clettwr and Leri), Rheidol, Ystwyth, Wyre, Aeron, Teifi, and Nevern. Of these, the Glaslyn and Dwyryd, the Mawddach, the Dyfi and subsidiaries, and the Teifi, form estuaries of considerable extent. After heavy rain, the inshore waters of the Bay are discoloured for some distance from the river-mouths. This discolouration is chiefly to the northward of the river mouths, owing to the surface waters being driven in that direction by the prevailing rain winds. The junction between the surface of the muddy fresh water (floating over sea water) and the clear sea is frequently plainly visible. The Bay is bounded for the most part by high land, but the continuity is broken by the deep clefts and estuaries of numerous rivers. The coast-line comprises an alternating series of (1) steep, rocky cliffs, consisting of Cambrian Ordovician and Silurian grits and shales, though there are some exposures of igneous rock, (2) drift cliffs of lower elevation, and (3) estuaries. In each of these the characteristics of the tidal area are different. In the first it is chiefly reef and hard erosion plane, with great variability in local conditions according to the strike and dip of the rock, the amount of exposure, and the quantity of detritus which washes to and fro in the gullies between the rock-ridges. If the strike of the rocks is fairly parallel with the coast, the dip of the rocks becomes an important factor as regards the Fauna. If it is low, the whole surface is exposed to wave action and the rocks are barren; if it is high with a landward dip, they are also barren; but if high and seaward, there may be a fairly good Fauna on the more sheltered landward slope. Outlying reefs may provide shelter, even if submerged, because they break the force of a ground swell and lessen the amount of wave-borne detritus. The shingle derived from boulder clay and carried along the coast is often largely augmented by detritus from the grit cliffs of the locality.

(2) Where drift cliffs prevail, much of the foreshore consists of shingle with large stretches, or low reefs of boulders, and local patches of coarse sand.

(3) In the estuaries, and often for some distance on either side, the tidal area is sandy or muddy and the foreshore is dune-capped. More recently there appears to have been a considerable influx of finer sand (presumably from deeper water) along the greater part of the shore-line,

resulting in appreciable local modifications of some of the elements of the Fauna.

The portion of the Bay in which the above-mentioned conditions are most typically developed lies between Portmadoc to the north and Cardigan to the south. Aberystwyth lies practically in the centre, and as the faunistic work has been carried out from that point, and since time, distance, and accessibility have, as usual, played their parts, the coast in the vicinity of Aberystwyth has been much more thoroughly examined than the rest. Practically no records have been made south of the Teifi, and but few above Portmadoc. It is fortunate that the region most readily accessible includes all the types of coast. It will be seen that there are three principal types of shore, and that these are subject in a marked degree to several important factors. (1) Wave disturbance (surf action). (2) Erosion by detritus and shingle. (3) Muddy fresh water.

These adverse conditions are reflected in the comparative poverty of the Fauna. In connection with the above factors, peculiarities have been observed in the distribution of certain groups, notably some of the Mollusca, and these are dealt with separately. It is hoped, later, to study the Fauna of the Bay below low-water mark and a number of records are already available : the comparison should prove of interest. It follows from what has been said above, that the shore Fauna will consist chiefly of the more hardy species, supplemented by some others that may survive in the more sheltered spots. The nomenclature adopted is mainly that of the "Plymouth Marine Invertebrate Fauna," 1904.

It will be observed that the Echinoderms and Ascidians are very poorly represented. The Crustacea and fishes have been limited as far as possible to shore forms, but a hard-and-fast line cannot be drawn. The worms have not been at all adequately examined and require the attention of a specialist. The following abbreviations are used to denote the observers responsible for the various records :—

H. J. F. = Prof. H. J. Fleure, D.Sc.
F. S. W. = F. S. Wright.
C. L. W. = C. L. Walton.

LIST OF LITTORAL ALGÆ.

A—Aberystwyth ; C—Clarach and north ; S—Allt Wen and south.

CHLOROPHYCEAE.

Enteromorpha compressa, Grev.; A, C, S.
Enteromorpha linza, J. Ag.; C.
Enteromorpha intestinalis, J. Ag.; A, C, S.
Ulva latissima, J. Ag.; A, C, S.
Chaetomorpha melagonium, Kütz.; A, S.
Chaetomorpha tortuosa, Kütz.; A.
Cladophora pellucida, Kütz.; A.
Cladophora albida, Kütz.; A, C.
Cladophora sericea, Reinb.
Bryopsis plumosa, C. Ag.; A, C.

PHAEOPHYCEAE.

Desmarestia aculeata, Lamx.; A, C.
Dictyosiphon fœniculaceus, Grev.; A.
Punctaria latifolia, Grev.; A, C.
Myriotrichia clavæformis, Harv.
var. filiformis, Farl.; A.
Asperococcus echinatus, Grev.; A.
Streblonema faciculatum, Thur.; A.
Ectocarpus confervoides, Le Jol.; A, C.
var. siliculosa, Kjell.
E. tomentosus, Lyngb.; A, S.
Elachista fucicola, Fries.; A.
Sphacelaria cirrhosa, C. Ag.; A.
Sphacelaria plumigera, Holm.; A.
Cladostephus spongiosus, C. Ag.; A, C, S.
Cladostephus verticillatus, C. Ag.; A,C.
Stypocaulon scoparium, Kütz.; C, S.
Ralfsia verrucosa, Aresch.; A.
Stilophora rhizodes, J. Ag.; S.
Chordaria flagelliformis, C. Ag.; A. S.
Mesoglœa vermiculata, Le Jol.; S.
Castagnea virescens, Thur.; A, S.
Castagnea griffithsiana, J. Ag.; A.
Leathesia difformis, Aresch.; A, C, S.
Phyllitis fascia, Kütz.; A.
Chorda filum, Stackh.; A.
Laminaria saccharina, Lamx.; A, C, S.
Laminaria digitata, Edm.; A, C, S.
Fucus cerenoides, Linn.; A.
Fucus vesiculosus, Linn.; A, C, S.
Fucus serratus, Linn.; A, C, S.
Ascophyllum nodosum, Le Jol.; A, C, S.
Pelvetia canaliculata, Dene eb, Thur.
Halidrys siliquosa, Lyngb.; A, C, S.
Dictyota dichotoma, Lamx.; S.

RHODOPHYCEAE.

Bangia fuscopurpurea, Lyngb.; C.
Porphyra linearis, Grev.; A.
Chantransia virgatula, Thur.
Chondrus crispus, Stackh.; A, S.
Gigartina teedii, Lamx.; A.
Phyllophora membranifolia, J. Ag.; A.
Ahnfeldtia plicata, Fries.; A.
Catanella spuntia.
Rhodymenia palmata, Grev.; A.
Lomentaria articulata, Lyngb.; A.
Laurencia hybrida, Lenorm.; S.
Polysiphonia urceolata, Grev.; A.
var. patens, J. Ag.
Polysiphonia elongata, Grev.; S.
Polysiphonia violacea, Wyatt ; A.
Polysiphonia nigrescens, Grev.; A.
Callithamnion hookeri, C. Ag.
Plumaria elegans, Bonnem.; S.
Ceramium strictum, Harv.
var. divaricata, Holm. & Batt. A.
C. diaphanum, Roth.; A.
C. rubrum, C. Ag.; A.
var. proliferum, J. Ag.
C. acanthonotum, Carm.; A.
C. ciliatum, Ducluz ; A.
Furcellaria fastigiata, Lamx.; S.
Polyides rotundus, Grev.; A.
Hildenbrandtia prototypus, Nard.
var. rosea, Kütz.; A, C, S.
Lithothamnion polymorphum, Aresch.; A, S.
Corallina officinalis, Linn.; A, C, S.

The region between Ystwyth and Dyfi appears to be hostile to certain *Algæ*, notably *Stilophora rhizoides*, *Mesoglœa vermiculata*, *Dictyota dichotoma* and *Laurencia hybrida*, which are absent from it, and *Chondrus crispus* and *Castagnea virescens*, which become more common outside it.

LIST OF SHORE FAUNA.

PORIFERA.

Sycon compressum, Fleming. Low-water mark, in sheltered spots, upon Algæ, etc. (H. J. F.; C. L. W.)

S. coronatum, Ellis and Sol. Same as last. (C. L. W.)

Halisarca dujardini, Johnston. Under surface of stones. (C. L. W.)

Halichondria panicea, Pallas. Common in sheltered spots almost everywhere. (C. L. W.)

Hymeniacidon sanguineum, Grant. Aberystwyth. (C. L. W.)

CŒLENTERATA.

Podocoryne carnea, M. Sars. Aberystwyth. (C. L. W.)

Coryne vaginata, Hincks. On Algæ in rock-pools or reefs south of Borth. (C. L. W.)

Zanclea implexa, Alder. One colony, collected by Dr. Salter, 1907. (C. L. W.)

Obelia dichotoma. On piles of Railway Wharf, Aberdovey, and rock-pools Gwbert-on-Sea. (C. L. W.)

O. geniculata, Linnæus. Generally distributed. (H. J. F.; C. L. W.)

Sertularia pumila, Linnæus. Generally distributed: often abundant on *Fucus*. (C. L. W.)

Plumularia echinulata, Lamarck. Aberystwyth. (C. L. W.)

P. pinnata, Linnæus. General in sheltered pools. (C. L. W.)

P. similis, Hincks. (H. J. F.)

Actinia equina, Linnæus. Generally distributed and locally common. Aberystwyth, Y-Gamlas, Mochras, etc. (C. L. W.) See Journal Marine Biological Association, October, 1911. pp. 228–230.

Anemonia sulcata, Penn. Generally only a few. Aberystwyth and for a few miles to the south. Tonfunau, etc. (C. L. W.)

Sagartia miniata, Gosse. One specimen. Aberystwyth. (C. L. W.)

S. undata, O. F. Müller. Observed at Clarach, a little bay to the north of Aberystwyth. Small specimens occur under stones which have become fixed in grooves, on an otherwise very barren erosion plane. Individuals, when kept in captivity, very averse to light. One large specimen on reef below the College. (C. L. W.)

S. ornata, Holdsworth. This rare Actinian has occurred in pools at extreme low water, on reefs below the University. (C. L. W.) See Journal Marine Biological Association, October, 1911. pp. 236–237.

Tealia coriacea, Cuvier. Not common, but occurs in favourable situations as in pools at Clarach, which are sheltered by large shelving rocks; there specimens of large size may be seen. One individual observed among Mussels at Mochras. (C. L. W.)

ECHINODERMATA.

Henricia sanguinolenta, O. F. Müller. One specimen. Aberystwyth; extreme low water, February, 1913. (C. L. W.)

Asterias rubens, Linnæus. Has been common 1898 and 1904–5, but now scarce, Aberystwyth. (H. J. F.) Sometimes occurs on the seaward Mussel beds, Aberdovey. (C. L. W.)

Amphiura sp. Not uncommon under stones. (C. L. W.)

Ophiothrix fragilis, O. F. Müller. A number were observed under stones among *Laminaria* during the abnormally low tides of February, 1913. (C. L. W.)

TURBELLARIA.

Fovia affinis, Stimpson. Under stones, near Harbour, Aberystwyth. (C. L. W.)

Leptoplana tremellaris, O. F. Müller. Common. (C. L. W.)

NEMERTINI.

Amphiporus lactifloreus, Johnston. Aberystwyth. (C. L. W.)

Lineus longissimus, Gunn. Aberystwyth. (H. J. F.)

Tetrastemma sp. Aberystwyth. (C. L. W.)

Dinophilus tæniatus, Harmer. Aberystwyth. (H. J. F.)

POLYCHÆTA.

Lagisca floccosa, Savigny. Aberystwyth. (C. L. W.)

Harmothoe imbricata, Linnæus. Gwbert-on-Sea, two specimens. (C. L. W.) Central dorsal area dark, margins pale.

Eulalia viridis, Müller. Frequent on reefs and with *Sabellaria*. (C. L. W.)

Psamathe fusca, Johnston. Aberystwyth. (C. L. W.)

Castalia punctata, Müller. Clarach, with ova, June 9th, 1910. (C. L. W.)

Nereis pelagica, Linnæus. Aberystwyth. (C. L. W.)

Lysidice sp. Aberystwyth. (C. L. W.)

Terebella sp. Fairly common. Aberystwyth. (C. L. W.)

Lanice conchilega, Pallas. Local. (C. L. W.)

Arenicola marina, Linnæus. Abundant on Cockle beds in estuaries. (C. L. W.)

Cirratulus cirratus, O. F. Müller. Aberystwyth. (H. J. F.)

Pomatoceros triqueter, Linnæus. Not uncommon under stones. (C. L. W.)

Spirorbis borealis, Daudin. General on *Fucus*, etc. (C. L. W.)

Sabellaria alveolata, Linnæus. Locally very abundant near sandy areas, and has then a considerable influence in binding together boulders and loose stones. It is almost invariably accompanied by *Eulalia viridis* and *Ulva*, but precludes many other species by filling up the crevices and bases of rocks and stones which otherwise afford them shelter. (C. L. W.)

GEPHYREA.

Sipunculus nudus, Linnæus. One specimen, Aberystwyth. (H. J. F.)

POLYZOA.

Scrupocellaria reptans, Linnæus. Aberystwyth. (C. L. W.)

Membranipora pilosa, Linnæus. Aberystwyth, etc. (C. L. W.)

M. membranacea, Linnæus. Aberystwyth. (C. L. W.)

Crisia cornuta, Linnæus. Under stones, Aberystwyth. (C. L. W.)

C. denticulata, Lamarck. Aberystwyth. (C. L. W.)

Alcyonidium hirsutum, Fleming. Upon *Alga*, Aberystwyth, Borth, etc. (C. L. W.)

Amathia lendigera, Linnæus. Upon old Mussels, Aberdovey. (C. L. W.)

Bowerbankia imbricata, Adams. With above. (C. L. W.)

Pedicellina cernua, Pallas. With *A. hirsutum*, Clarach. (C. L. W.)

MOLLUSCA.

Acanthochites fascicularis, Linnæus. Aberystwyth, etc. (C. L. W.)

Trachydermon cinereus, Linnæus. Aberystwyth. (H. J. F.) Morva, Clarach. (C. L. W.)

Patella vulgata, Linnæus. Abundant ; mainly on the sheltered landward side of shelving rocks, and then often of very large size. (C. L. W.)

Helcion pellucida, Linnæus. Aberystwyth, above extreme low tides rather rare. (H. J. F.) Fairly common on *Laminaria* when tides are unusually low. (C. L. W.) Coves, Gwbert-on-Sea, fairly common. (C. L. W.) One specimen was discovered near Aberystwyth at high-water mark attached to a stone, evidently due to *Laminaria* cast up after storms.

Fissurella græca, Linnæus. One specimen, Aberystwyth. (H. J. F.)

Acmæa virginea, Müller. Llanina, near New Quay, one specimen. (C. L. W.) Shells are fairly frequent. (H. J. F.)

Gibbula magus, Linnæus. Y-Gamlas, near Pwllheli. (C. L. W.)

G. cineraria, Linnæus. Rare. Two living specimens south of Llanrhystyd and two at Gwbert-on-Sea. (C. L. W.)

G. umbilicata, Montagu. Very abundant in certain areas. (H. J. F.; C. L. W.) New Quay, Llanrhystyd, north of Towyn, Mochras, near Pwllheli, etc. Considerable differences in form and colouration are observable. The general shell form varies from a dorso-ventrally flattened or "Tam-o'-Shanter," to a clumsy rounded turban shape. In the latter the summit is generally eroded and the penultimate whorl often imbricate and inflated. These differences appear to be due to age. The umbilicus varies between large, open, and deep, and narrow, slit-like, and shallow. These differences appear equally in local examples and in specimens sent from Plymouth, and do not depend entirely upon age and size; as in several instances the umbilicus was wider and deeper as size increased. The narrowing appears to be due to growth of the adjacent edge of the inner lip, which takes place in some individuals, but not in others. The colour bands may be few and obvious, or numerous and obscure.

Monodonta crassa, Montfort. Distribution more restricted than the last; often very abundant and large. (C. L. W.)

Calliostoma zizyphinus, Linnæus. One small specimen, Aberystwyth. (C. L. W.)

Phasianella pullus, Linnæus. One specimen, on *Laminaria*, extreme low water, Aberystwyth. (C. L. W.)

Lacuna divaricata, Fabricius. On *Algæ*, not uncommon. (C. L. W.)

L. puteolus, Turton. Aberystwyth, one specimen living among *Balanus perforatus*. (C. L. W.)

Littorina littorea, Linnæus. Common almost everywhere. Strongly ribbed when young, ribbings becoming either faint or obsolete after a height of 20 mm. has been attained. (C. L. W.)

L. neritoides, Linnæus. Seldom common, but widely distributed. (C. L. W.)

L. obtusata, Linnæus. Abundant everywhere, on *Fucus*. (H. J. F.; C. L. W.)

L. rudis, Maton. Abundant almost everywhere. The largest shell so far found in the Bay is from Aberdovey. Total length, 19 mm.;

greatest diameter, 13 mm.; aperture of mouth, 11 mm. long, 8 mm. broad. Shell thick, apex acute.

Paludestrina stagnalis, Baster (Hydrobia ulvæ). Exceedingly abundant on sands, Ynys Lâs, Dyfi estuary; and on stones and muddy sand at Borth-y-Gest, Glaslyn estuary. (C. L. W.)

Trivia europea, Montagu. Rare, Aberystwyth. (H. J. F.)

Purpura lapillus, Linnæus. Abundant. (H. J. F.; C. L. W.)

Nassa reticulata, Linnæus. Aberystwyth, not common. (H. J. F.)

Æolidia papillosa, Linnæus. Aberystwyth, etc., not uncommon. (H. J. F.; C. L. W.)

Aeolidiella augulata, Alder and Hancock. One specimen under a stone very low water, Aberystwyth, February 22nd, 1913. (C. L. W.)

Æ. glauca, Alder and Hancock. Rocks below College.

Facelina drummondi, Thompson. Aberystwyth. (H. J. F.)

F. coronata, Forbes and Goodsir. Not uncommon, Aberystwyth. (C. L. W.)

Doto coronata, Gmelin. Aberystwyth. (H. J. F.)

Archidoris tuberculata, Alder and Hancock. Gwbert, near New Quay, Aberystwyth, Clarach, etc. (H. J. F.; C. L. W.)

Jorunna johnstoni, Alder and Hancock, Aberystwyth. (C. L. W.)

Polycera lessoni, D'Orbigny. Rare, Aberystwyth. (C. L. W.)

Acanthodoris pilosa, Müller. Aberystwyth, rare. (C. L. W.)

Lamellidoris bilamellata, Linnæus. Aberystwyth, Llannia, Gwbert, etc. (C. L. W.)

Goniodoris castanea, Alder and Hancock. One specimen, Aberystwyth, on *Botryllus violaceus* coating *Halidrys*. (C. L. W.)

G. nodosa, Montagu. Not uncommon,. Aberystwyth, Clarach, etc. (C. L. W.)

Ancula cristata, Alder. Aberystwyth. (C. L. W.)

Anomia ephippium, Linnæus. Fairly common under stones. (H. J. F.)

Mytilus edulis, Linnæus. Locally very abundant on shores and in estuaries. Small where marine conditions prevail; large and of considerable commercial importance in the estuaries of Portmadoc, Barmouth, and Aberdovey. (C. L. W.)

Volsella barbata, Linnæus. Two specimens among *Sabellaria*, Clarach, 1906. One, Aberystwyth, 1913. (C. L. W.)

Scrobicularia plana, da Costa. In mud on the Cockle beds of the various estuaries. (C. L. W.)

Tellina tenuis, da Costa. One living specimen among Cockles, Ynys Lâs, Dyfi estuary. (C. L. W.)

Macoma balthica, Linnæus. Abundant on Cockle beds. (C. L. W.)

Donax vittatus, da Costa. Borth. (C. L. W.)

Tapes decussatus, Linnæus. Aberystwyth. (H. J. F.; F. S. W.) Occasionally; Aberdovey, not uncommon; Monk's Cave (south of Aberystwyth). (C. L. W.)

T. virgineus, Linnæus. Borth, etc. (C. L. W.)

Cardium edule, Linnæus. Very abundant in the various estuaries (C. L. W.)

Saxicava rugosa, Linnæus. Aberystwyth, Clarach, etc. Often with *Sabellaria*. (H. J. F.; C. L. W.)

CRUSTACEA.

[I am indebted to Mr. F. S. Wright for this list, and the records are his unless otherwise indicated.]

Canthocamptus palustris, Brady. Aberystwyth, Clarach, etc. (H. J. F.)

Balanus balanoides, Linnæus. Aberystwyth. (H. J. F.)

B. perforatus, Bruguière. Aberystwyth, etc. (C. L. W.)

Chthamalus stellatus, Poli. Aberystwyth, etc. (C. L. W.)

Verruca strœmia, O. F. Müller. Aberystwyth, etc. (C. L. W.)

Sacculina carcini, Thompson. Aberystwyth, etc. On Carcinus. (H. J. F.; C. L. W.)

Dexamine spinosa, Montagu. Aberystwyth. Common.

Amathilla homari, Fabricius. Two specimens in stony pools, very low water, Aberystwyth. (C. L. W.)

Gammarus pulex, de Geer. Aberystwyth, etc., common.

G. locusta, Linnæus. Aberystwyth, etc., common.

Caprella linearis, Linnæus. At low water, Aberystwyth.

Calliopius læviusculus, Kroyer. Aberystwyth and Clarach.

Idotea baltica, Pallas, Aberystwyth.

I. marina, Linnæus. Aberystwyth.

Sphæroma serratum, Fabricius. Aberystwyth, common.

Jæra marina, Fabricius. Aberystwyth, common under stones. (C. L. W. F. S. W.)

Gnathia edwardii, Spence Bate. A female was discovered under a fixed stone in a deep pool. It occupied a burrow within a colony of *Halichondria panicea*, and within the burrow were found a number of small yellow ova, June 24th, 1910.

Ligia oceanica, Linnæus. Common.

Leander serratus, Pennant. Aberystwyth, common.

Crangon vulgaris, Linnæus. Common.

Hippolyte varians, Leach. Aberystwyth. (C. L. W.; H. J. F.)

Athanas nitescens, Leach. Occasional, Aberystwyth.

Axius stirhynchus, Leach. One specimen, March 24th, 1909, at extreme low water, Aberystwyth, in a handful of gravelly sand. Kept in confinement in a glass vessel with a little sand, it kept the water turbid by constant movement of the swimmerets. The identification was confirmed by Canon A. M. Norman.

Homarus vulgaris, Milne-Edwards. Sometimes found at low-tide mark on rocky shores. (C. L. W.)

Galathea squamifera, Leach. Aberystwyth. In sheltered areas not subject to severe wave action. Generally in early summer, but appearance very erratic; sometimes abundant, at others rare or absent. (H. J. F.) A number occurred during the very low tide of February 21st–22nd, 1913. (C. L. W.) One specimen, October, 1912, Gwbert. (C. L. W.)

Porcellana platycheles, Pennant. Abundant under stones.

P. longicornis, Linnæus. Extreme low water, Aberystwyth. Appearance very uncertain. (H. J. F.)

Dromia vulgaris, Milne-Edwards. One small specimen, Aberystwyth. (H. J. F.)

Eupagurus bernhardus, Linnæus. Common.

Portunus puber, Linnæus. Not uncommon, Aberystwyth, etc.

Carcinus mænas, Pennant. Common.

Cancer pagurus, Linnæus. Common.

Pilumnus hirtellus, Linnæus. Rare.

Pinnotheres pisum, Linnæus. Appears to be abundant with *Mytilus edulis*, Aberdovey, etc. (C. L. W.)

PYCNOGONIDA.

Pycnogonum littorale, Strœm. Aberystwyth. (H. J. F.)

Nymphon gracile, Leach. Upon *Plumularia pinnata*. (F. S. W.)

TUNICATA.

Styelopsis grossularia, van Beneden. One specimen, Aberystwyth. (C. L. W.)

Botryllus violaceus, M.-Edwards. Common under stones, Aberystwyth, etc. (H. J. F.; C. L. W.)

Botrylloides sp. Aberystwyth.

PISCES.

Blennius pholis, Linnæus. Common and often very large. (F. S. W.; H. J. F.)

B. gattorugine, Bloch. Aberystwyth, occasionally. (F. S. W.)

Cottus bubalis, Euphrasen. Fairly common and large, in rock-pools. (F. S. W.; H. J. F.)

Centronotus gunnellus, Bloch. Fairly common. (F. S. W.)

Onos (Motella) mustelus, Linnæus. Common, often high in tidal zone. (H. J. F.; F. S. W.)

O. (Motella) tricirratus, Bloch. One specimen, Aberystwyth, February 22nd, 1913. (C. L. W.)

Lepadogaster decandolii, Risso. One specimen found at Aberystwyth during a low spring tide, March, 1909. (F. S. W.)

Liparis montagui, Donovan. Specimens have occurred occasionally in tide-pools below the University. (F. S. W.)

L. vulgaris, Fleming. Occasional young specimens, Aberystwyth. (F. S. W.)

Nerophis lumbriciformis, Willoughby. Scarce; two specimens in half-tide pools, Aberystwyth. (F. S. W.)

Gasterosteus spinachia, Linnæus. Rare, Aberystwyth. (H. J. F.)

Crenilabrus melops, Cuvier. Two young specimens, Aberystwyth. (F. S. W.) One, February, 1913. (C. L. W.) Summer, 1910.

Ctenolabrus rupestris, Linnæus. Fairly common. (H. J. F.; F. S. W.)

Cyclopterus lumpus, Linnæus. Fairly common. (H. J. F.; F. S. W.)

Trachinus draco, Linnæus. Rare, Aberdovey. (H. J. F.)

Zeugopterus punctatus, Bloch. Occasional. (H. J. F.; C. L. W.) One specimen was obtained clinging to the under surface of a stone by means of the margins of the body. I have since seen this species adhere to the sides of a tank in Plymouth Aquarium, in a similar manner. (C. L. W.)

The Distribution of some Littoral Trochidæ and Littorinidæ in Cardigan Bay.

By

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The physical characteristics of the Bay having been set out in the preceding paper, it will not be necessary to repeat that description here, since only special local features will be dealt with, as occasion arises. Peculiarities of distribution had been noted for the Trochidæ and Littorinidæ, and it was with a view to obtaining further information as to the operation of local littoral conditions and their effects upon the fauna that these groups were more particularly examined. These notes detail some of the peculiarities, and outline what are believed to be the controlling causes, at any rate for the central area of the Bay. It would be of great interest to know whether similar peculiarities have been, or can be, observed for other areas of coast. The region discussed lies between Gwbert-on-Sea at the mouth of the Teifi, to the south; and a point a few miles beyond Pwllheli to the north. The portion more closely examined extends from near Llanrhystyd, some eight miles south of Aberystwyth, to Mochras, a few miles south of Harlech. Some observations were also made about Portmadoc, Borth-y-Gest, and Pwllheli in the northern part of the Bay; and about New Quay, and the mouth of the Teifi to the south, the most southerly being some miles below Cemmæs Head.

Much of the coast is difficult of access, and the investigation has been going on for a number of years.

The following species have been observed living within tide marks :—

Trochidæ.

(1) *Gibbula cineraria* (Linnæus).
(2) *G. umbilicata* (Montagu).
(3) *G. magus* (Linnæus).
(4) *Monodonta crassa* (Montfort).
(5) *Calliostoma zizyphinus* (Linnæus).

LITTORINIDÆ.

(6) *Littorina littorea* (Linnæus).
(7) *L. neritoides* (Linnæus).
(8) *L. obtusata* (Linnæus).
(9) *L. rudis* (Maton).

GENERAL DISTRIBUTION.

(1) *G. cineraria.*—This species is rare throughout the whole of the region examined. Two large living specimens were obtained after careful search. in the coves at Gwbert; these coves are situated seaward of the bar, and their general fauna is rich (for Cardigan Bay). Two small specimens were also found, under stones about eight miles south of Aberystwyth. Dead shells are not infrequent, so that this species may be more abundant below tide marks.

(2) *G. umbilicata* is, in certain districts, exceedingly abundant; but at Gwbert, in the coves above mentioned, I found but two. In New Quay Bay it abounds, also locally from Llanrhystyd (and probably between there and New Quay) to within some two miles of the River Ystwyth, where it gradually dies out. Further north it reappears near Towyn to the north of the Dysynni. It is abundant about Mochras, and occurs at Y-Gamlas on the Zostera beds beyond Pwllheli. There it is accompanied by (3) *G. magus*, the only locality for this fine species that has so far been noted in the Bay.

(4) *M. crassa* has very much the same distribution as *G. umbilicata*, but its range is more restricted, and always lies within the area occupied by that species. Both are often exceedingly abundant for considerable distances.

(5) *C. zizyphinus.*—So far only one small living specimen has been recorded, and that at Aberystwyth, where no other species of the Trochidæ exist. It probably occurs in deeper water.

(6) *Littorina littorea* has a wide distribution, but is more especially abundant and much larger in certain places.

(7) *L. neritoides* is, as elsewhere, very local. Its distribution around the Bay appears to be quite normal and to be governed by its usual requirements; a rocky foreshore, affording crevices just above high-water mark, and not exposed to the midday sun and the resulting desiccation. Given these conditions, it often will occur in very restricted areas. South of Aberystwyth, the foreshore for considerable distances is chiefly smooth rock, with a steep seaward inclination. One or two large squared masses of fallen cliff are situated just about high-water

mark, and their stratified wall-like sides afford crevices, inhabited by this species and *L. rudis*. *L. neritoides*, however, only occurs on the upper portions, and on the N. and E. faces. A few may be observed on the S.E. also, but this is exceptional. I have seen practically the same thing in similar positions on the Devon coast. On the sea walls of the promenade at Aberystwyth, this species occurs, chiefly where the rays of the summer sun will not strike about midday.

(8) *L. obtusata* occurs throughout the littoral region examined wherever *Fucus* grows, and hence is the most thoroughly persistent form.

(9) *L. rudis.*—This also is generally present, and frequently exceedingly abundant. It usually accompanies *L. littorea* in its distribution, though at a somewhat different level. These two frequently appear and disappear simultaneously, but one or other may be locally dominant.

VERTICAL DISTRIBUTION.

The distribution of the species may also be considered vertically, that is, in zones. These zones, of course, overlap considerably and are seldom all well developed, or even present in any given locality. By contrasting varying localities a general succession appears. This is not by any means arbitrary, as some of these zones may occur intermixed at times, particularly in the case of *M. crassa*, *L. littorea*, and *L. obtusata*. *L. neritoides* is constant when conditions permit, and *L. obtusata* is dependent on the presence of Fucoid Algæ. *C. zizyphinus* has occurred once, but in its normal position.

Allowing for local differentiation and overlap, the succession is, more or less, as follows :—

L. neritoides.
L. rudis.
$\left\{\begin{array}{l}\textit{M. crassa.}\\ \textit{L. obtusata.}\\ \textit{L. littorea.}\end{array}\right.$
G. umbilicata. *G. magus.*
G. cineraria.
C. zizyphinus.

The succession of the Littorinidæ can be best followed in the Aberystwyth district, where the Trochidæ are absent.

On the sea wall of the promenade below the University the following succession can be observed :—

(*a*) Barren stonework.
(*b*) Zone of *L. neritoides.*

(*c*) Zone of small green *Algæ* and many *L. rudis*.

(*d*) ,, ,, few scattered Fucoids and a few *L. rudis*.

(*e*) ,, ,, thick coating of *Fucus* and a few *L. obtusata*.

(*f*) Base of wall, with pools at foot, with *Enteromorpha*, *Ulva*, etc., and *L. littorea*.

M. crassa is local in Cardigan Bay, but often extremely abundant; and in the area south of Aberystwyth exhibits a striking peculiarity in that it there breaks zone by following fresh-water influence, sometimes as far as the low-water mark of spring-tide; it is then often of remarkable size. Proceeding southwards from Aberystwyth, the mouths of the Rheidol and Ystwyth and a storm beach are passed, and a high slaty cliff with eroded rocky foreshore is reached. About halfway around this headland (Allt Wen), i.e. two miles from Aberystwyth, *G. umbilicatus* puts in an appearance, at first only sporadically, two or three small individuals here and there. As it becomes more numerous, *M. crassa* also appears, and both increase rapidly to the south of the headland, where the cliffs are composed of glacial drift. A number of springs flow down, and in one or two localities fresh water percolates through a shingle bank on the foreshore, and affects more or less the whole of the lower rocky and stony portions of the tidal region, which is there mainly composed of boulders covered to some extent by Algæ. Where there is fresh-water influence, *M. crassa* follows it. Streamlets often follow a kind of channel or gutter, where the boulders lie less thickly, and the shore level is somewhat lower. In these channels, *M. crassa* swarms upon the nearly bare boulders, and extends almost to low water. *G. umbilicata* is seldom to be observed within the fresh-water influence, although abundant close by. Where a section of the shore is affected by fresh water, *M. crassa* tends to become abundant throughout. It appears to feed upon minute *Algæ*, and I am indebted to Dr. Fleure for a recent attempt to determine the food of this species: all that could be made out, however, was that "the contents of the gut consisted of finely triturated vegetable matter, too fragmentary for identification." H. J. Fleure and M. M. Gettings state (Q.J.M.S., 1907), "*T. crassus* [*M. crassa*] is found to some extent with the previous species [*G. umbilicata*], but it lives, for the most part, near high-tide level, so much so that specimens may remain for a considerable time in corners washed only by high spring-tides. It crawls over the rocks chiefly at half-tide level, but is more lethargic than *T. obliquatus* [*G. umbilicata*], and less inclined to browse on the larger *Algæ*. During stormy periods, especially in winter, numbers may be found huddled in sheltered nooks, often with a number of *Littorina littorea* as companions. As is well known, the spire of *T. obliquatus* is much lower than that of *T. crassus*, and this is probably correlated with the greater activity of the former in the shore zone, where a high spire would give too much purchase to a side blow from a wave." Recent observations lead to the same conclusions: the animals crowd the tops of the boulders in calm summer weather, and in winter tend to occupy the sides and angles of boulders and reef-pools.

It is evident that in this region Trochus is extending its range northward. Quite recently Mr. W. Whitehouse informed me that he had seen specimens on the Aberystwyth side of Allt Wen. This I found to be the case, as I found a colony of *G. umbilicata* and one specimen of *G. cineraria* about the spot indicated. This is well to the north of any other record, but is close to an isolated patch of boulder clay. I have examined this spot at intervals ever since 1906, and Prof. Fleure knew it well for some years before that, and no Trochi have ever been seen there.

A remarkable influence of fresh water in larger volume upon the littoral Mollusca has been noted, about the mouths of several of the smaller rivers. It is particularly noticeable for some half-mile or so on either side of the mouth of the Afon Wyre, near Llanrhystyd. The cliffs thereabouts are very low, and composed of glacial drift, with the usual result that the foreshore consists of shingle, while the lower portion of the tidal region is occupied by boulders of medium size. These extend to low-water mark, but pass into sand and shingle both to the N. and to the S.; and this boulder area is fairly well covered with Algal growth. The river debouches upon a shingle bed, and spreads out in a fan-like manner over the boulders; and, to judge by the distribution of mussels, would appear, as usual, to trend up-coast, at least during some states of the tide. To the south of the river where the boulder area commences (and, indeed, throughout the area) the zones of *L. neritoides* and the upper portion of that of *L. rudis* are absent owing to the presence of shingle. The boulders are at first considerably incrusted with *Sabellaria*, and no Mollusca are present except a few specimens of *Patella*, probably owing to the proximity of much sand and shingle. As the boulder area widens *G. umbilicata* appears, and rapidly becomes abundant. That lack of shelter and attrition are the excluding factors is borne out by the fact that, where *Gibbula* first appears, the shells of many are much worn and eroded, and in several cases actually broken. I examined certainly 1000 *Gibbulas*, and only discovered two specimens of *cineraria*.

Both were small, flattened, and occurred beneath stones. *L. obtusata* accompanies *Fucus*, and is the most persistent species throughout. *L. littorea* appears about the same time as *G. umbilicata*, but does not become abundant until fresh-water influence is an appreciable factor; it then increases in number and size. *G. umbilicata* is dominant for a considerable distance, but as the river is approached, *M. crassa* appears, here one and there one, amidst the crowds of *Gibbula*. Those first noticed are rather small, but there is a gradual increase in size and abundance until it equals *G. umbilicata* in numbers. That species then dies out as fresh water is approached, and is replaced by a rather squat, solid, smooth form of *L. rudis*, which in its turn rapidly becomes larger and more numerous, while *M. crassa*, after being a dominant species for a while, dies out in its turn. Then for a space, *L. rudis* and *L. littorea* alone occupy the ground; but both are absent from the actual flow of the stream. On the northern side of the river, mussels are abundant in the crevices of the stones for some distance along the shore, and are accompanied by *L. rudis* and *L. littorea*. Then, as the mussels disappear, *M. crassa* reappears, and in company with the Littorinas becomes very abundant. *G. umbilicata* recommences by degrees, increases in numbers, and with *M. crassa* continues until the boulder area once more gives place to shingle.

This lateral distribution or zoning may be expressed thus (the order in each instance is that of abundance):—

1.	2.	3.	4.
G. umbilicata.	*G. umbilicata.*	*G. umbilicata.*	*G. umbilicata.*
	L. littorea.	*L. littorea.*	*M. crassa.*
	G. cineraria.	*M. crassa.*	*L. littorea.*
		G. cineraria.	

Littorina obtusata. . . . .

5.	6.	7.	8.
M. crassa.	*L. rudis.*	*L. rudis.*	*L. rudis-littorea.*
L. littorea.	*L. littorea.*	*L. littorea.*	
G. umbilicata.	*M. crassa.*	*M. crassa.*	
L. rudis.	*G. umbilicata.*		

. . . *Littorina obtusata.* . . . . . .

	1.	2.	3.	4.	
River.	*L. littorea-rudis.*	*L. rudis-littorea. M. crassa.*	*L. rudis-L. littorea. M. crassa.*	*M. crassa.* *G. umbilicata.*	} *L. littorea-rudis.*

The Littorinidæ.

It may be mentioned that the shells of *L. obtusata* often bear a striking resemblance in both form and colour to the vesicles and conceptacles of the species of *Fucus* upon which they live ; so much so, in fact, that when collecting this species, I have more than once mistaken the vesicles of the *Algœ* for the shell of the Mollusc.

The conceptacles of all the species of *Fucus* are of shades varying from white to bright yellow, and, indeed, the whole of the parts of the plant exposed to sunlight are frequently much lighter in hue than the more sheltered portions, which are usually dark brown or olive. One would expect that the lighter coloured forms of *L. obtusata* would tend to occur upon the surface, and the darker among the masses of the plant. I have made a considerable number of observations in the district with the object of testing this idea. What I have found is, that the darkest varieties are seldom found upon the surface of the Algal masses, and that the majority of varieties are found in abundance crawling on the exterior, but are often in harmony with their surroundings. It may be mentioned that many shells which appear out of harmony, are not so in reality, the change of colour being due to drying of the shell during low water. The greatest resemblance is between the light brown and yellow-shelled varieties and the vesicles of *F. vesiculosus* and between the colour of the frond and the ordinary brown and olive shells. Bright yellow *Littorinas* may be found at times upon the dark stems of the Algæ, and are then very conspicuous. I do not find the yellow variety to be really common in the district.

The Littorinidæ persist in the areas devoid of Trochidæ ; and, as has already been stated, *L. obtusata* appears to be less affected by the adverse conditions than the other species ; this is in all probability largely due to the protection afforded it by the food plant, and its shell-characters. *L. rudis* and *L. littorea*, are neither so large, so numerous, nor so evenly distributed as in the areas where Trochidæ are abundant. Several varieties of *L. rudis* occur in Cardigan Bay, and of these *tenebrosa*, Montagu, has so far only been found under stones some three miles south of Aberystwyth on a portion of the shore influenced by fresh water. This influence was sufficiently strong to attract a number of eels which were also hiding under the stones. Tryon describes the variety as " thin, whorls rounded, with elevated spire, brownish or yellowish, usually tessellated with white." In the Aberystwyth specimens the ribbings of the shell are not very strong, and the colour olive-green to greyish. The chequered appearance is due to the presence of a series of short white streaks disposed in a spiral sequence ; these white marks, alternating in each turn of the spiral produce a chequered appearance. The usual forms, *similis* and *lævis* of Jeffreys, were both present in the same locality. The variety *patula*, Thorpe, is sometimes abundant on steep rocks at the foot of cliffs, somewhat influenced by fresh-water springs, and may be yellow, olive-green, pale greenish white, black and white in bands, or pinkish ; *compressa*, Jeffreys, occurs a little to the south of Aberystwyth.

The complete sequence of species of Littorina may be interrupted, and a barren area may occur between the cliff rocks and the lower tidal reefs, owing to a belt of shingle. The result of this truncation of zone is that the upper portion of the *rudis* zone may be absent except here and there where conditions allow ; while below the break, *rudis* and *littorea* may be found together in quantity, giving the impression that the latter is above its usual horizon.

Dr. Fleure considers that *L. rudis* spawns largely in the shelter afforded by the interior of dead *Balanus*, and I have found many of the young of both *rudis* and *littoralis* so small as to be just recognizable clustered within the angles of empty *Balanus*. The absence of *Balanus* from the *rudis* zone may also have a limiting effect, locally, on the distribution of the species. A curious and interesting form of Molluscan association is common on some parts of the cockle beds of the Dyfi estuary, and usually on the more muddy areas. Scattered over from one to several acres in such places, are clusters, or groups, composed primarily of one or more mussels, attached to either various dead shells which lie upon the surface, or to one or more living cockles of varying sizes. The latter occupy their usual positions in the sand, thus anchoring the mussels. Upon the cockles grow trailing tufts of various green *Algæ*, and clinging to the mass are generally several individuals of *L. littorea* and *L. rudis*, more often the former. Within the mass, amongst the byssal threads of the mussels, one or more specimens of *Macoma balthica* are frequently to be found. There are often a dozen individuals, belonging to five species of Mollusca, involved in these clusters.

Factors Governing Distribution.

The facts concerning distribution, association, etc., are matters of observation, record, and comparison ; the causes of distribution are problems of a much more difficult nature, and require careful consideration following wide investigation. With regard to the distribution of the Trochidæ in Cardigan Bay, it is not yet possible to state that the problem has been completely elucidated. It would appear, however, that there is a correlation between such distribution and shore drainage. The barren area receives most of its shore drainage from lime-free slates and grits, while the "Trochus" areas receive water from boulder clay in the southern, and the same, and igneous rocks, in the northern portions of the Bay. The streamlets followed by *M. crassa* drain from boulder clay. An attempt was made to obtain additional data by a comparison of the *Algæ* from various portions of the Aberystwyth district. Certain differences were discovered (see list of *Algæ*), but none of them appear to have any direct connection with the Mollusca under consideration; and the evidence afforded is thus more cumulative than decisive. The boulder clays of different districts appear to have different lime contents. The water of the New Quay district is "hard," fruit trees grow well there and the drifts probably contain lime, whereas the boulder clay from the region drained by the Ystwyth has been analysed by Dr. T. C. James, and found to be quite devoid of lime. The northerly drift along the coast has been mentioned already; and it is noteworthy that drainage from the areas containing lime would tend to influence the coast some distance northward on that account. The limeless drainage of the Ystwyth, moreover, coincides with an area of slate and shale rocks; and this is the most barren as regards Trochidæ. The reappearance of the Trochidæ to the north again coincides with the reappearance of boulder clay, and river drainage from districts containing volcanic rock, etc.

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Marine Biological Association of the United Kingdom.

Report of the Council, 1912.

The Council and Officers.

The Council have to record with regret the death of the Duke of Abercorn, who had been a Vice-President since the foundation of the Association, of Professor Adam Sedgwick, F.R.S., for many years a member of the Council, and of Mr. G. H. Drew, who became a member of Council in June last.

The thanks of the Council are due to the President and Council of the Royal Society for the use of the rooms in which their meetings have been held.

The Plymouth Laboratory.

The work done during the spring of 1912 to the front walls and roof of the building has proved efficient in keeping out the damp, and as regards the structure everything appears now to be in good order. The machinery and apparatus both of the Aquarium and the Laboratory have been maintained in an efficient state.

The Boats.

Owing to the state of the finances the steamer *Oithona* was laid up somewhat earlier than usual. The collecting work has since been done by the sailing boat *Anton Dohrn* and the small motor-boat which was presented to the Laboratory by Colonel G. M. Giles.

It has been decided to sell the *Anton Dohrn*, which has done good service during the last ten years, and to replace her by a new sailing boat of similar type.

The Staff.

The staff at work at the Laboratory has consisted of the Director, Dr. E. J. Allen; Hydrographer, Mr. D. J. Matthews, and three

Naturalists, Messrs. L. R. Crawshay, J. H. Orton and R. S. Clark. The latter has recently been appointed to make investigations on the biology of marketable fishes.

Occupation of Tables.

The following Naturalists have occupied tables at the Plymouth Laboratory since the last report was presented to the Association:—

Prof. Chas. Chilton, d.sc., New Zealand (Amphipoda).
J. Clark, d.sc., Kilmarnock (Crustacea).
W. De Morgan, Plymouth (Protozoa).
G. H. Drew, b.a., Plymouth (Tissue Growth).
F. Martin Duncan, Oxted (Photography of Marine Animals).
H. M. Fuchs, Cambridge (Echinoderm Development).
J. Gray, Cambridge (Echinoderm Development).
H. Henry, m.d., Sheffield (Parasitic Protozoa).
G. J. Hill, London (General Zoology).
H. B. Johnston, Oundle (General Zoology).
S. P. Kramer, m.d., New York (Elasmobranchs).
Miss D. Jordan Lloyd, Cambridge (Echinoderm Development).
Mrs. Matthews, Plymouth (Development of Alcyonium).
C. A. Newman, Oundle (General Zoology).
Guy de Pitard, Berne (Anemones).
C. Shearer, m.a., Cambridge (Dinophilus and Echinoderm Development).
Geoffrey Smith, m.a., Oxford (Blood of Carcinus).
C. L. Walton, Aberystwyth (Anemones).

General Work at the Plymouth Laboratory.

During the six months covered by the present report the staff have for the most part been employed in a continuation of the researches then described. The Director's experiments on the conditions of growth of plankton diatoms have made considerable progress and results of great scientific interest are promised. Mr. Matthews's investigations on the chemistry of sea-water have to some extent been interrupted by the preparation of a report on the hydrographical work of the Irish Fishery Department, by whom Mr. Matthews is in part employed.

Mr. L. R. Crawshay's report on the fauna of the deeper portion of the English Channel to the south-west of the Eddystone has been published in the Journal of the Association. This report, in conjunction with the previous papers by Mr. Crawshay and Mr. Worth on the bottom-deposits of this region, forms a valuable addition to our knowledge of the English Channel both from the biological and geological points of view.

Mr. Crawshay has since the completion of this work been engaged with considerable success in experimental work on rearing copepods and other plankton animals in the Laboratory, with a view to working out the details of their life-histories, a subject upon which very much remains to be done.

In addition to extending the general faunistic records of the Plymouth neighbourhood Mr. J. H. Orton has been specially studying the rate of growth of invertebrates. A large collection of material and of data has been brought together, and an important contribution to our knowledge of this comparatively unworked subject is anticipated when the work is reported upon.

Mr. R. S. Clark is continuing the investigations on the mackerel fisheries off the Cornish coast which were commenced some years ago by the Director and Mr. Bullen. There seems reason to hope that a thorough investigation of the causes which induce the migrations of this fish may make it possible to assist the fishermen in finding the shoals.

The work of Messrs. Shearer, De Morgan and Fuchs, who have been further assisted by Messrs. J. Gray and L. Doncaster and Miss D. Jordan Lloyd, on the hybridization of Echinoids and the rearing of parthenogenetic echinoderm larvæ, has been published in a number of papers in the Quarterly Journal of Microscopical Science, which have attracted considerable attention.

Mrs. Matthews has been investigating the development of *Alcyonium* and has been able to obtain all stages from the fertilized egg to the fixed polyp in considerable numbers.

Mrs. Sexton and Mrs. Matthews have been studying a species of brackish-water *Gammarus* with a view to determining the nature of the variations in structure or appearance which are brought about by changes in the conditions under which the animals live. They have succeeded in rearing five generations in about six months, and they now have the animals living and breeding both in entirely fresh water and in sea-water of normal salinity.

Published Memoirs.

The following papers, either wholly or in part the outcome of work done at the Laboratory, have been published elsewhere than in the Journal of the Association :—

DONCASTER, L., and GRAY, J. *Cytological Observations on the Early Stages of Segmentation of Echinus Hybrids.* Quart. Journ. Micr. Sci., vol. 58, 1912–13, pp. 483-509.

FUCHS, H. M. *On Echinoderm Hybridisation.* Rept. Brit. Assoc. Adv. Sci., 1912.

FUCHS, H. M. *The Inheritance of the Aboral Process of the Echinocardium Pluteus.* Arch. f. Entwick. d. Organismen., Bd. 35, pp. 558–68.

GRAY, J. *The Effects of Hypertonic Solutions upon the Eggs of Echinus.* Proc. Camb. Phil. Soc., vol. 17, 1913, pp. 1–6.

GRAY, J. *The Effects of Hypertonic Solutions upon the Fertilised Eggs of Echinus (E. esculentus and E. acutus).* Quart. Journ. Micr. Sci., vol. 58, 1912–13, pp. 447–81.

IKEDA, I. *Studies on some Sporozoan parasites of Sipunculoids. I. The Life-History of a New Actinomyxidian, Tetractinomyxon intermedium g. et sp. nov.* Arch. f. Protistenkunde, Bd. 25, 1912, pp. 240–72.

NICHOLLS, G. E. *The Structure and Development of Reissner's Fibre and the Sub-commissural Organ.* Quart. Journ. Micr. Sci., vol. 58, 1912, pp. 1–116.

NICOLL, W. *On two new Trematode Parasites from British Food-Fishes.* Parasitology, vol. 5, 1912, pp. 197–202.

SEXTON, E. W. *Some Brackish-water Amphipoda from the mouths of the Weser and the Elbe, and from the Baltic.* Proc. Zool. Soc., Lond., 1912, pp. 656–65.

SHEARER, C. *The Problem of Sex Determination in Dinophilus gyrociliatus. Pt. I. The Sexual Cycle.* Quart. Journ. Micr. Sci., vol. 57, 1912, pp. 329–71.

SHEARER, C., DE MORGAN, W., and FUCHS, H. M. *On Paternal Characters in Echinoid Hybrids.* Quart. Journ. Micr. Sci., vol. 58, 1912, pp. 337–52.

SHEARER, C., and LLOYD, D. J. *On methods of Producing Artificial Parthenogenesis in Echinus esculentus and the Rearing of the Parthenogenetic plutei through Metamorphosis.* Quart. Journ. Micr. Sci., vol. 58, 1912–13, pp. 523–49.

WIJNHOFF, G. *Die Systematik der Nemertinen.* Zoologischen Anzeiger, Bd. 40, October, 1912.

The Library.

The thanks of the Association are due for the following books and current numbers of periodicals presented to the Library during the period June 1st to Dec. 31st, 1912:—

Académie Imp. des Sciences de St. Pétersbourg. Bulletin.
American Museum of Natural History. Annual Report.
American Microscopical Society. Transactions.
American Philosophical Society. Proceedings.
Armstrong College. Calendar.
Arendals Fiskeriselskab Beretning.
Australian Museum. Records.
Bergens Museum. Aarbok.
—— Skrifter.
Bernice Pauahi Bishop Museum, Honolulu. Occasional Papers.
Board of Agriculture and Fisheries. Annual Report of Proceedings under Acts relating to Sea Fisheries.
—— Monthly Return of Sea Fisheries, England and Wales.
—— Report of Proceedings of Annual Meeting.
—— Report upon the Epidemic amongst Salmonidæ in the summer of 1911.
—— Statistical Tables.
—— Memorandum on German Eel Culture.
Boston Society of Natural History. Proceedings.

British Museum. Catalogue of the Chætopoda in the British Museum (Natural History). Arenicolidæ.
—— National Antarctic Expedition, 1901–4. Zoology and Botany.
Bulletin Scientifique de la France et de la Belgique.
Bureau of Science, Philippine Islands. Journal of Science.
California Academy of Sciences. Proceedings.
Club Montanyenc, Barcelona. Butlletí.
College of Science, Tokyo. Journal.
Colombo Museum. Spolia Zeylanica.
R. Comitato Talassografico Italiano. Bollettino.
—— Memoria.
—— Bollettino delle Crociere Periodiche.
Comité du Laboratoire de Carlsberg. Comptes Rendus.
Conchological Society of Great Britain and Ireland. Journal of Conchology.
Connecticut Academy of Arts and Sciences. Transactions.
Conseil perm. internat. pour l'Exploration de la Mer. Bulletin Hydrographique.
—— Bulletin Planktonique.
—— Bulletin Statistique.
—— Publications de Circonstance.
—— Rapports et Procès-Verbaux des Réunions.
Cornwall Sea Fisheries Committee. Reports.
Cuerpo de Ingenieros de Minas del Peru. Boletin.
Dept. of Agriculture, etc., Ireland. Report.
Dept. of Commerce and Labor, Bureau of Fisheries, U.S.A. Bulletin.
—— Pamphlets.
Dept. of Marine and Fisheries, Canada. Annual Report.
Dept. of Trade and Customs, Melbourne. Zoological Results of the Fishing Experiments carried out by the F.I.S. *Endeavour* 1909–10.
Deutschen Fischerei-Vereins. Zeitschrift für Fischerei.
Deutscher Seefischerei-Verein. Mitteilungen.
Dove Marine Laboratory. Report.
Falmouth Observatory. Meteorological and Magnetic Reports.
La Feuille des Jeunes Naturalistes.
Field Museum of Natural History. Publications.
Finnländische Hydrographisch-Biologische Untersuchungen. Abhandlungen.
—— Tidvattnen i Östersjon och Finska viken. By R. Witting.
Fisheries Society of Japan. Journal.
The Fisherman's Nautical Almanac. By O. T. Olsen.
Fishery Board of Scotland. Annual Report.
—— Scientific Investigations.
—— Fisheries and Marine Motor Exhibition, Copenhagen, 1912. Report on Fishing Boat Motor Engines exhibited, etc. By Capt. J. R. M'Ewan.
Fiskeri-Beretning.
Government Museum, Madras. Report.
Guernsey Society of Natural Science. Report and Transactions.
Illinois State Laboratory of Natural History. Bulletin.
Imperial Bureau of Fisheries, Japan. Report.
Imperial Fisheries Institute, Japan. Journal.
—— Report.

Indian Museum. An Account of the Deep-Sea Asteroidea collected by the R.I.M.S.S. *Investigator*. By R. Koehler.
—— An Account of the Shallow Water Asteroidea. By R. Koehler.
—— An Account of the Littoral Holothurioidea. By R. Koehler and C. Vaney.
—— Catalogue of the Indian Decapod Crustacea. By A. Alcock.
—— The Alcyonarians of the Deep Sea. By J. A. Thomson and W. D. Henderson.
—— The Alcyonarians of the Littoral Area. By J. A. Thomson and J. J. Simpson.
Institut für Meereskunde, Berlin. Veröffentlichungen.
Institut Océanographique. Annales.
Institut de Zoologie, Montpellier. Travaux.
R. Irish Academy. Proceedings.
Kommission zur wissenschaftlichen Untersuchung der Deutschen Meere, etc. Wissenschaftliche Meeresuntersuchungen.
Kommissionen für Havundersögelser, Copenhagen. Meddelelser.
K. Bayerischen Akademie der Wissenschaften, München. Abhandlungen.
—— Sitzungsberichte.
Kgl. Danske Videnskabernes Selskab. Oversigt.
Laboratoire Biologique de St. Pétersbourg. Bulletin.
Laguna Marine Laboratory. Report.
Lancashire Sea Fisheries Laboratory. Report.
Lancashire and Western Sea Fisheries. Superintendent's Report.
Linnean Society. Transactions.
Linnean Society of New South Wales. Proceedings.
Liverpool Biological Society. Proceedings and Transactions.
Los Angeles Zoological Society. Proceedings.
Marine Biological Association of the West of Scotland. Report.
Marine Biological Laboratory, Woods Hole. Biological Bulletin.
Marine Biological Station, Port Erin. Report.
Mark Anniversary Volume.
Mededeelingen over Visscherij.
Meteorological Office. Barometer Manual.
—— Geophysical Manual.
—— Monthly Pilot Charts.
—— Annual Report of the Committee.
R. Microscopical Society. Journal.
Ministère de l'Instruction publique, France. Deuxième Expédition Antarctique Française (1908–1910).
Musée Océanographique de Monaco. Bulletin.
Museo Nacional, Buenos Aires. Anales.
Museo Zoologico, Napoli. Annuario.
Museum of Comparative Zoology, Harvard College. Bulletin.
—— Memoirs.
—— Report.
Muséum National d'Histoire Naturelle, Paris. Bulletin.
The Museums Journal.
Nederlandsche Dierkundige Vereeniging. Tijdschrift.
—— Verslag.
New York Academy of Sciences. Annals.

New York Zoological Society. Bulletin.
—— Report.
—— Zoologica.
New Zealand Institute. Transactions and Proceedings.
Norges Fiskeristyrelse. Aarsberetning vedkommende Norges Fiskerier.
La Nuova Notarisia.
Oberlin College. The Wilson Bulletin.
Owens College, Manchester. The Dorsal Vibrate Fin of the Rockling (*Motella*). By J. S. Thomson.
—— Observations on living Gorgonias (*Gorgonia verrucosa*) occurring in the English Channel. By J. S. Thomson.
—— Observations on some Alcyonaria from Singapore. By E. W. Shann.
—— The Presence of Maxillulæ in Larvæ of Dytiscidæ. By J. Mangan.
—— Structure of the Alimentary Canal of the Stick-Insect, *Bacillus rosii* Fabr. By A. E. Cameron.
Physiographiske Forening, Christiania. Nyt Magazin for Naturvidenskaberne.
Quarterly Journal of Microscopical Science. (Presented by Sir E. Ray Lankester, K.C.B., F.R.S.)
Rijksinstituut voor het Onderzoek der Zee. Helder. Jaarboek.
Royal Society of Edinburgh. Proceedings.
—— Transactions.
Royal Society of London. Philosophical Transactions.
—— Proceedings.
Royal Society of Victoria. Proceedings.
Scottish Microscopical Society. Proceedings.
Selskabet for de Norske Fiskeriers Fremme. Norsk Fiskeritidende.
Smithsonian Institution. New Diptera from Panama. By J. R. Malloch.
—— A Study of the Salinity of the Surface Water in the North Pacific Ocean and in the adjacent enclosed Seas. By A. H. Clark.
Societas pro Fauna et Flora Fennica. Acta.
Société Belge de Géologie, etc. Bulletin.
Société Centrale d'Aquiculture et de Pêche. Bulletin.
Société l'Enseignement des Pêches Maritimes. Bulletin Trimestriel.
Société Imp. Russe de Pisciculture et de Pêche. Vyestnīk R'ibopom'shlennostī.
Société Zoologique de France. Bulletin.
South African Museum. Annals.
Kgl. Svenska Vetenskaps-Akademien. Arkiv för Botanik.
—— Arkiv för Zoologie.
—— Handlingar.
Tôhoku Imperial University, Japan. Science Reports.
Torquay Natural History Society. Journal.
Transvaal Museum. Annals.
Tufts College. Studies.
United States National Herbarium. Contributions.
United States National Museum. Bulletin.
—— Proceedings.
R. Università di Napoli. Lavori fatti nell' Istituto di Anatomia comparata.
—— Apparati Reticolari Sarcolemma nella fibra muscolare cardiaca. By M. Fedele.

R. Università di Napoli. La morfologia della cromatina dal punto di vista fisico. By P. Della Valle.
University of California. Publications. Zoology, Physiology, Botany.
University College Library, London. Catalogue.
University of Toronto. Studies.
Kgl. Vetenskaps Societeten, Upsala. Nova Acta.
Visscherij-Station, Batavia. Mededeelingen.
Zoological Museum, Copenhagen. The Danish Ingolf-Expedition.
Zoological Society of Japan. Annotationes Zoologicæ Japonenses.
Zoological Society of London. Proceedings.
—— Transactions.
Zoologische Sammlung des Bayerischen Staates. Beiträge zur Naturgeschichte Ostasiens.
Zoologisches Museum, Berlin. Bericht.
—— Mitteilungen.

Dr. H. R. Mill. Symons's Meteorological Magazine.
Mrs. Hill. A number of works from the library of her brother, the late W. I. Beaumont.

To the authors of the Memoirs mentioned below the thanks of the Association are due for separate copies of their works presented to the Library:—

Barroso, M. G. Briozoos de la Estación de Biología Marítima de Santander.
Billard, A. Hydroïdes de Roscoff.
Breitfuss, L. L. Wissenschaftlich-praktische Murman-Expedition. Bericht über die Tätigkeit pro 1905.
Buchanan, J. Y. Experimental Researches on the Specific Gravity and the Displacement of some Saline Solutions.
Burrows, M. T. A Method of Furnishing a Continuous Supply of New Medium to a Tissue Culture in Vitro.
—— Rhythmische Kontraktionen der isolieren Herzmuskelzelle ausserhalb des Organismus.
—— The Growth of Tissues of the Chick Embryo outside the Animal Body, with Special Reference to the Nervous System.
Carrel, A., and Burrows, M. T. Cultivation of Tissues in Vitro and its Technique.
—— Cultivation in Vitro of the Thyroid Gland.
—— Cultivation in Vitro of Malignant Tumors.
Caullery, M. Présence de Physalies et de Vélelles dans le Pas-de-Calais au début d'Avril, 1912.
Clark, J. An Annotated List of Cornish Fishes.
—— Notes on Cornish Crustacea. I. Brachyura and Macrura.
Cotton, A. D. Clare Island Survey. Marine Algæ.
Crossland, C. Supplement to the "Physical Description of Khor Dongonab, Red Sea."
Dakin, W. J. Aquatic animals and their environment. The Constitution of the external medium and its effect upon the blood.
Davenport, C. B. Light thrown by the Experimental Study of Heredity upon the Factors and Methods of Evolution.

Donnison, H. Report on Crab Investigations.

Drew, G. H. An Experimental Investigation of the Cytological Changes produced in Epithelial Cells by long-continued Irritation.

Fabre-Domergue. Épuration bactérienne des Huîtres par la stabulation en eau de mer artificielle filtrée.

—— Nouvelles expériences sur l'épuration bactériologique des huîtres en eau filtrée.

—— Instructions pour l'établissement et l'emploi de bassins de stabulation destinés à l'épuration des Huîtres et autres Mollesques comestibles.

Farran, G. P. Plankton from Christmas Island, Indian Ocean. I. On Copepoda of the Family Corycæidæ.

—— Clare Island Survey. Decapoda.

Fauvel, P. Sur quelques Néréidiens (*Perinereis Marionii* Aud. Edw. *P. macropus* Clap. *Neanthes succinea* Leuck.).

Freund, L. Krankheiten der Fische.

Gemmill, J. F. Laboratory Aquarium Notes.

—— Aerator suitable for Laboratory Aquaria.

—— Notes on the Adult Anatomy of *Solaster endeca* (Forbes).

—— The Locomotor Function of the Lantern in Echinus, with Observations on other Allied Lantern Activities.

—— The Development of the Starfish, *Solaster endeca* (Forbes).

Goodrich, E. S. Nerilla an Archiannelid.

—— Observations on the Nephridia of the Alciopinæ.

Hartmeyer, R. Revision von Heller's Ascidien aus der Adria.

Helland-Hansen, B., and Nansen, F. The Sea West of Spitsbergen. The Oceanographic Observations of the Isachsen Spitsbergen Expedition in 1910.

Heron-Allen, E., and Earland, A. On some Foraminifera from the North Sea, etc., dredged by the Fisheries Cruiser *Goldseeker* (International North Sea Investigations—Scotland). I. On some New Astrorhizidæ and their Shell Structure.

Hornell, J. New Cestodes from Indian Fishes.

Hoyle, W. E. The Cephalopoda of the Scottish National Antarctic Expedition.

Ikeda, I. Studies on some Sporozoan parasites of Sipunculoids. I. The Life-History of a new Actinomyxidian, *Tetractinomyxon intermedium g. et sp. nov.*

Issel, R. Biologica neritica mediterranea. Il bentos animale delle foglie di Posidonia studiato dal punto di vista bionomico.

—— Biologica neritica mediterranea, Richerche di etologia sull' Isopodo tubicolo. Zenobiana prismatica (Risso).

Kofoid, C. A. Protozoa.

Korotneff, A. A. Die Planarien des Baikal-Sees (Tricladen).

Lee, A. B. L'étape strepsinématique des auxocytes mâles de l'Escargot.

Lohmann, H. Die Probleme der modernen Planktonforschung.

M'Intosh, W. C. Notes from Gatty Marine Laboratory.

Man, J. G. de. Sur quelques "Palæmonidæ" et sur une espèce de "Penaeus" de l'Afrique occidentale avec des observations sur le "Palæmon (Eupalæmon) acanthurus" Wiegm. de l'Amérique du Sud.

—— *Odontopharynx longicaudata* n. g. n. sp. Eine neue Form von Anguilluliden.

Mines, G. R. An accessory time signal for use in experiments where the recording apparatus is not run continuously.

—— Functional Analysis by the action of electrolytes.

—— Some observations on electrocardiograms of cold blooded animals.

—— Some observations on Electrograms of the Frog's Heart.

—— Calcium Salts in Relation to Neuromuscular Mechanisms.

Nicoll, W. On two new Trematode Parasites from British Food-Fishes.

Nilsson, D. Beiträge zur Kenntnis des Nerven-systems der Polychaeten.

Orton, J. H. An Account of the Natural History of the Slipper Limpet.

Pax, F. Hypertrophie bei Actinienlarven.

—— La paléontologie et la distribution géographique des Actinies.

—— Aktinienstudien.

—— Vorarbeiten zu einer Revision der Familie Actiniidæ.

—— Studien an Westindischen Actinien.

—— Aktinien der Aru-Inseln.

—— Die Aktinien der Ostafrikanischen Inseln.

—— Die Steinkorallen der Deutsche Südpolar-Expedition, 1901–1903.

—— Anthozoa. Die Aktinien-fauna Westafrikas.

Popta, C. M. L. Fortsetzung der Beschreibung von neuen Fischarten der Sunda-Expedition.

—— Die geographische Verbreitung der Süsswasserfische zwischen Asien und Australien.

Reinke, E. A Preliminary Account of the Development of the Apyrene Spermatozoa in *Strombus* and of the Nurse-cells in *Littorina*.

Schaxel, J. Zur Analysis des Spiraltypus der Annelidenfurchung bei normalen und abnormen Verlauf.

—— Weitere Untersuchungen über die Eibildung der Meduse Pelagia.

Schmidt, J. Contributions to the biology of some North Atlantic species of Eels.

Sexton, E. W. Some Brackish-Water Amphipoda from the Mouths of the Weser and the Elbe, and from the Baltic.

Shearer, C. The Problem of Sex Determination in *Dinophilus gyrociliatus*. Pt. I. The Sexual Cycle.

Tattersall, W. M. Clare Island Survey. Cumacea, Schizopoda, etc.

Van Name, W. G. Simple Ascidians of the Coasts of New England and Neighbouring British Provinces.

Viguier, C. Nouvelles études sur le Plankton de la Baie d'Alger.

Donations and Receipts.

The receipts for the seven months ending December 31st, 1912, include the grants from His Majesty's Treasury (£1000) and the Board of Agriculture and Fisheries, Development Fund (£500), Special Donations (£26), Annual Subscriptions (£71), Rent of Tables in the Laboratory (£86), Sale of Specimens (£299), Admission to Tank Room (£81).

Vice-Presidents, Officers, and Council.

The following is the list of gentlemen proposed by the Council for election for the year 1913–14:—

President.

Sir E. Ray Lankester, K.C.B., LL.D., F.R.S.

Vice-Presidents.

The Duke of Bedford, K.G.
The Earl of Ducie, F.R.S.
The Earl of Stradbroke, C.V.O., C.B.
Lord Avebury, F.R.S.
Lord Walsingham, F.R.S.
The Right Hon. A. J. Balfour, M.P., F.R.S.
The Right Hon. Joseph Chamberlain, M.P.
The Right Hon. Austen Chamberlain, M.P.
W. Astor, Esq., M.P.
G. A. Boulenger, Esq., F.R.S.
A. C. L. Günther, Esq., F.R.S.
A. R. Steel-Maitland, Esq., M.P.
Sir John Murray, K.C.B., F.R.S.
Rev. Canon Norman, D.C.L., F.R.S.
Edwin Waterhouse, Esq.

Members of Council.

E. T. Browne, Esq.
L. W. Byrne, Esq.
W. T. Calman, Esq., D.Sc.
Prof. H. J. Fleure, D.Sc.
Prof. F. W. Gamble, D.Sc., F.R.S.
Sir Eustace Gurney.
Commander M. W. Campbell Hepworth, C.B., R.N.R.
Prof. J. P. Hill, D.Sc., F.R.S.
E. W. L. Holt, Esq.
Prof. E. W. MacBride, D.Sc., F.R.S.
H. G. Maurice, Esq.
Edgar Schuster, Esq., D.Sc.
Geoffrey W. Smith, Esq.
Prof. D'Arcy W. Thompson, C.B.

Chairman of Council.

A. E. Shipley, Esq., D.Sc., F.R.S.

Hon. Treasurer.

J. A. Travers, Esq., Tortington, Arundel.

Hon. Secretary.

E. J. Allen, Esq., D.Sc., The Laboratory, Citadel Hill, Plymouth.

The following Governors are also members of the Council:—

G. P. Bidder, Esq., M.A.
The Earl of Portsmouth (Prime Warden of the Fishmongers' Company).
Sir Richard Martin, Bart. (Fishmongers' Company).
The Hon. Nathaniel Charles Rothschild (Fishmongers' Company).
Prof. G. C. Bourne, D.Sc., F.R.S. (Oxford University).
A. E. Shipley, Esq., D.Sc., F.R.S. (Cambridge University).
Prof. W. A. Herdman, D.Sc., F.R.S. (British Association).

Dr.

Statement of Receipts and Payments for

				£	s.	d.	£	s.	d.
To Current Income :—									
H.M. Treasury for year ending 31st March, 1913 ...				1,000	0	0			
Annual Subscriptions				71	8	0			
Rent of Tables, including £50 from the University of London, on account of 1911, 1912, and 1913 ...				86	0	0	1,157	8	0
,, Extraordinary Receipts :—									
Donations—									
Dr. C. Shearer (part payment as Founder)	24	1	3						
Dr. S. P. Kramer	1	10	0						
C. A. Newman	0	19	0	26	10	3			
Board of Agriculture and Fisheries, Grant from Development Fund, for year ending 31st March, 1913				500	0	0	526	10	3
The Balance is apportioned as follows :—									
Repairs and Renewals				200	0	0			
Less General Account overdrawn				54	2	4			
				£145	17	8			
							£1,683	18	3

Examined and found correct.

(Signed) N. E. Waterhouse, F.C.A.
L. W. Byrne.
Eustace Gurney.
W. T. Calman.

3 Frederick's Place,
Old Jewry, E.C.
6th February, 1913.

the Seven Months ending 31*st December*, 1912. **Cr.**

				£	s.	d.	£	s.	d.
By Balance from Last Year :—									
Loan from Bank				400	0	0			
Overdraft at Bank				63	1	0			
				463	1	0			
Less Cash at Bank	120	10	8						
Cash in hand	0	1	2	120	11	10	342	9	2
,, Current Expenditure :—									
Salaries and Wages—									
Director (Half Year)				100	0	0			
Hydrographer				87	10	0			
Naturalist (Five Months)				104	3	4			
Additional Naturalist				98	4	0			
Assistant Naturalist				101	0	0			
Salaries, Wages, and Compensation paid				353	12	9			
				844	10	1			
Less Compensation recovered from Employers' Liability Corporation				24	3	0	820	7	1
Travelling Expenses							30	19	4
Library				46	4	8			
Less Duplicates sold				0	2	6	46	2	2
Journal				80	1	3			
Less Sales				4	8	10	75	12	5
Buildings and Public Tank Room—									
Gas, Water, and Coal				44	3	2			
Stocking Tanks and Feeding				30	7	4			
Maintenance and Renewals				184	2	1			
Rent, Rates, Taxes, and Insurance				33	15	2			
				292	7	9			
Less Admission to Tank Room				80	14	2	211	13	7
Laboratory, Boats, and Sundry Expenses—									
Glass, Apparatus, and Chemicals				104	15	10			
Less Sales				49	14	8			
				55	1	2			
Purchase of Specimens				51	0	1			
Maintenance and Renewal of Boats, Nets, Gear, etc.	139	5	10						
Less Sales, etc.	95	18	8	43	7	2			
Hire of Boats				22	2	2			
Insurance of s.y. *Oithona*	32	13	0						
Less Rebate	13	15	5	18	17	7			
Coal and Water for Steamer				30	15	9			
Stationery, Office Expenses, Carriage, Printing, etc.				81	10	5			
				302	14	4			
Less Sale of Specimens				299	0	10	3	13	6
,, Bank Interest							7	3	4
,, Balance :—									
Cash at Bankers				135	11	10			
Cash in hand				10	5	10	145	17	8
							£1,683	18	3

Marine Biological Association of the United Kingdom.

LIST
OF
Governors, Founders, and Members.

1st OCTOBER, 1913.

* Member of Council. † Vice-President. ‡ President.

Ann. signifies that the Member is liable to an Annual Subscription of One Guinea.

C. signifies that he has paid a Composition Fee of Fifteen Guineas in lieu of Annual Subscription.

I.—Governors.

The British Association for the Advancement of Science, *Burlington House, W.*	£500
The University of Oxford	£500
The University of Cambridge	£500
The Worshipful Company of Clothworkers, 41, *Mincing Lane, E.C.*	£500
The Worshipful Company of Fishmongers, *London Bridge, E.C.*	£10,705
Bayly, Robert (the late)	£1000
Bayly, John (the late)	£600
Thomasson, J. P. (the late)	£970
G. P. Bidder, Esq., *Cavendish Corner, Cambridge*	£1500

II.—Founders.

1884	The Corporation of the City of London	£210
1884	The Worshipful Company of Mercers, *Mercers' Hall, Cheapside*	£341 5s.
1884	The Worshipful Company of Goldsmiths, *Goldsmiths' Hall, E.C.*	£100
1884	The Royal Microscopical Society, 20, *Hanover Square, W.*	£100
1884	The Royal Society, *Burlington House, Piccadilly, W.*	£350
1884	The Zoological Society, *Regent's Park, London, N.W.*	£100
1884	Bulteel, Thos. (the late)	£100
1884	Burdett-Coutts, W. L. A. Bartlett, 1, *Stratton Street, Piccadilly, W.*	£100
1884	Crisp, Sir Frank, Bart., Treas. Linn. Soc., 17, *Throgmorton Avenue, E.C.*	£100
1884	Daubeny, Captain Giles A.	£100
1884	Eddy, J. Ray, *The Grange, Carleton, Skipton*	£100
1884	Gassiott, John P. (the late)	£100

‡1884	Lankester, Sir E. Ray, K.C.B., F.R.S., 29, *Thurloe Place, South Kensington, S.W.*	£100
1884	The Rt. Hon. Lord Masham (the late)	£100
1884	Moseley, Prof. H. N., F.R.S. (the late)	£100
1884	The Rt. Hon. Lord Avebury, F.R.S. (the late)	£100
1884	Poulton, Prof. Edward B., M.A., F.R.S., *Wykeham House, Oxford*	£100
1884	Romanes, G. J., LL.D., F.R.S. (the late)	£100
1884	Worthington, James (the late)	£100
1885	Derby, the late Earl of	£100
1887	Weldon, Prof. W. F. R., F.R.S. (the late)	£100
1888	Bury, Henry, M.A., *Mayfield House, Farnham, Surrey*	£100
1888	The Worshipful Company of Drapers, *Drapers' Hall, E.C.*	£315
1889	The Worshipful Company of Grocers, *Poultry, E.C.*	£120
1889	Thompson, Sir Henry, Bart. (the late)	£110
1889	Revelstoke, The late Lord	£100
1890	Riches, T. H., B.A., *Kitwells, Shenley, Herts*	£230
1902	Gurney, Robert, *Ingham Old Hall, Stalham, Norfolk*	£105
1909	Harding, Colonel W., *The Hall, Madingley, Cambridge*	£100
†1910	Murray, Sir John, K.C.B., F.R.S., *Challenger Lodge, Wardie, Edinburgh*	£100
1912	Swithinbank, H., F.R.S.E., F.R.G.S., *Denham Court, Denham, Bucks.*	£100
1913	Shearer, Dr. Cresswell, 30, *Thompson's Lane, Cambridge*	£100

III.—Members.

1913	Adams, Alfred, M.B., B.Ch., Oxon., *Looe, Cornwall*	Ann.
1897	Adams, W. R., *Howfield*, 111, *Denmark Hill, Camberwell, London, S.E.*	Ann.
1900	Aders, Dr. W. M., *Zanzibar, East Africa*	Ann.
*1895	Allen, E. J., D.Sc., *The Laboratory, Plymouth*	Ann.
1889	Alward, G. L., *Enfield Villa, Humberstone Avenue, Waltham, Grimsby*	Ann.
1910	Ashworth, J. H., D.Sc., *The University, Edinburgh*	Ann.
1892	Assheton, R., M.A., *Riversdale, Grantchester, Cambridge*	£20
†1911	Astor, W., M.P., 4, *St. James's Square, London, W.*	*C.*
1910	Atkinson, G. T., 43, *Parliament Street, London, S.W.*	Ann.
1902	Baker, R. J., 3, *Ash Villas, Collings Park, Mannamead, Plymouth*	Ann.
1884	Balfour, Prof. Bayley, F.R.S., *Royal Botanic Gardens, Edinburgh*	*C.*
1908	Ballard, Edward, *Zomba, Nyasaland, E. Africa*	Ann.
1884	Bayliss, Prof. W. Maddock, D.Sc., F.R.S., *St. Cuthberts, West Heath Road, Hampstead*	Ann.
1884	Bayly, Miss, *Seven Trees, Plymouth*	£50
1884	Bayly, Miss Anna, *Seven Trees, Plymouth*	£50
1885	Beck, Conrad, 68, *Cornhill, E.C.*	*C.*
1884	Beddington, Alfred H., 8, *Cornwall Terrace, Regent's Park, N.W.*	*C.*
†1907	Bedford, His Grace the Duke of, K.G., *Endsleigh, Tavistock*	*C.* & Ann. £10 10s.
1903	Bidder, Capt. H. F., *Ravensbury Manor, Mitcham*	Ann.
1910	Bidder, Mrs. M. G., *Cavendish Corner, Cambridge*	Ann.
1912	Bles, E. J., *Elterholm, Madingley Road, Cambridge*	Ann.
1910	Bloomer, H. H., 40, *Bennett's Hill, Birmingham*	Ann.
1910	Borley, J. O., M.A., 43, *Parliament Street, London, S.W.*	Ann.
*1884	Bourne, Prof. Gilbert C., M.A., F.R.S., *Savile House, Mansfield Road, Oxford*	Ann.

1910 Bowkett, Sidney, 40, *Old Bond Street, London* .... Ann.
1898 Bowles, Col. Henry, *Forty Hall, Enfield* .... Ann.
1910 Bradford, Sir J. Rose, K.C.M.G., M.D., D.Sc., F.R.S., 8, *Manchester Square, London, W.* .... Ann.
1910 Bridgman, F. J., *Zoological Department, University College, London* ... Ann.
1902 Brighton Public Library (Henry D. Roberts, Chief Librarian) .... Ann.
1886 Brooksbank, Mrs. M., *Leigh Place, Godstone, Surrey* .... *C.*
1884 Brown, Arthur W. W., 62, *Carlisle Mansions, Carlisle Place, London, S.W.* *C.*
*1893 Browne, Edward T., B.A., *Anglefield, Berkhamsted* .... Ann.
1892 Browne, Mrs. E. T., *Anglefield, Berkhamsted* .... Ann.
*1897 Byrne, L. W., B.A., 7, *New Square, Lincoln's Inn, London, W.C.* .... Ann.

*1908 Calman, Dr. W. T., *British Museum (Natural History), Cromwell Road, S.W.* .... Ann.
1912 Cavers, Dr. F., *Goldsmith's College, New Cross, London, S.E.* .... Ann.
†1884 Chamberlain, Rt. Hon. J., M.P., 40, *Prince's Gardens, S.W.* .... Ann.
1913 Childs, Christopher, M.D., *Boscarne, Looe* .... Ann.
1911 Chilton, Prof. C., *Canterbury College, Christchurch, New Zealand* .... Ann.
1884 Christy, Thomas Howard .... *C.*
1911 Clark, Dr. J., *Technical School, Kilmarnock, N.B.* .... Ann.
1910 Clarke, G. S. R. Kitson, *Meanwoodside, Leeds* .... Ann.
1887 Clarke, Rt. Hon. Sir E., K.C., 5, *Essex Court, Temple, E.C.* £25
1886 Coates and Co., *Southside Street, Plymouth* .... *C.*
1885 Collier Bros., *George Street, Plymouth* .... *C.*
1900 Cooper, W. F., B.A., *Ashlyns Hall, Berkhamsted* .... Ann.
1909 Crawshay, L. R., M.A., *The Laboratory, Plymouth* .... Ann.

1910 Darbishire, A. D., M.A., *The Zoological Department, The University, Edinburgh* .... Ann.
1885 Darwin, Sir Francis, F.R.S., 10, *Madingley Road, Cambridge* .... *C.*
1885 Darwin, W. E., *Ridgemount Bassett, Southampton* £20
1911 Davies, Humphreys, 6, *Southwick Place, London, W.* .... Ann.
1906 De Morgan, W. C., *c/o National Provincial Bank, Plymouth* .... Ann.
1908 Dendy, Prof. A., F.R.S., *Dale Lodge, Hampstead Heath, N.W.* .... Ann.
1910 Devonport Education Authority .... Ann.
1884 Dewick, Rev. E. S., M.A., F.G.S., 26, *Oxford Square, Hyde Park, W.* ... *C.*
1885 Dixey, F. A., M.A. Oxon., *Wadham College, Oxford* ....£26 5*s.* *and* Ann.
1910 Dobell, C. C., M.A., *Imperial College of Science and Technology, South Kensington, S.W.* .... Ann.
1890 Driesch, Hans, Ph.D., *Philosophenweg* 5, *Heidelberg, Germany* .... *C.*
†1889 Ducie, The Rt. Hon. the Earl of, F.R.S., *Tortworth Court, Falfield, R.S.O.* £50 15*s.*
1910 Duncan, F. Martin, *The Cottage, The Avenue, St. Margaret's, Twickenham* Ann.
1884 Dunning, J. W., 4, *Talbot Square, London, W.* ....£26 5*s.*
1884 Dyer, Sir W. T. Thiselton, M.A., K.C.M.G., F.R.S., *The Ferns, Witcombe, Gloucester* .... *C.*

1906 Elliott, Sir Thomas H., K.C.B., *The Royal Mint, Tower Hill, London, E.* .... Ann.
1908 Elwes, Maj. Ernest V., *Glendower, St. Albans Road, Babbacombe* .... Ann.
1913 Evans, Lewis, 16, *Hornton Court, Kensington, London, W.* .... *C.*

1913	Evans, Thomas Adam, 16, *Hornton Court, Kensington, London, W.*	Ann.
1885	Ewart, Prof. J. Cossar, M.D., *University, Edinburgh*	£25
1894	Ferrier, Sir David, M.A., M.D., F.R.S., 34, *Cavendish Square, W.*	Ann.
1884	Fison, Sir Frederick W., Bart., *Boarzell, Hurst Green, Sussex*	*C.*
*1913	Fleure, Prof. H. J., D.Sc., *University College of Wales, Aberystwyth*	Ann.
1897	Foster, Richard, *Windsworth, Looe, R.S.O.*	Ann.
1885	Fowler, G. Herbert, B.A., Ph.D., *The Old House, Aspley Guise, Bedfordshire*	Ann.
1884	Fry, George, F.L.S., *Carlin Brae, Berwick-on-Tweed*	£21
1912	Fuchs, H. M. de F., *Zoological Department, Imperial College of Science and Technology, South Kensington, S.W.*	Ann.
*1907	Gamble, Prof. F. W., D.Sc., F.R.S., 38, *Frederick Road, Edgbaston, Birmingham*	Ann.
1906	Gardiner, Prof. J. Stanley, M.A., F.R.S., *Caius College, Cambridge*	Ann.
1907	Garstang, Prof. W., D.Sc., 2, *Ridge Mount, Cliff Road, Headingley, Leeds*	Ann
1885	Gaskell, W. H., F.R.S., *The Uplands, Shelford, Cambridge*	*C.*
1901	Giles, Col. G. M.	*C.*
1910	Gooding, H. C., *Ipswich Street, Stowmarket*	Ann.
1910	Goodrich, E. S., F.R.S., *Merton College, Oxford*	Ann.
1885	Gordon, Rev. J. M., *St. John's Vicarage, Redhill, Surrey*	Ann.
1912	Gray, J., *King's College, Cambridge*	Ann.
1899	Guinness, Hon. Rupert, *Elveden, Thetford*	£35 15*s.*
†1884	Günther, Dr. Albert, F.R.S., 2, *Lichfield Road, Kew Gardens*	Ann.
*1900	Gurney, Sir Eustace, *Sprowston Hall, Norwich*	Ann.
1884	Halliburton, Prof. W. D., M.D., F.R.S., *Church Cottage*, 17, *Marylebone Road, London, W.*	Ann.
1909	Hamilton, Dr. G. C.	Ann.
1884	Hannah, Robert, 82, *Addison Road, Kensington, W.*	*C.*
1885	Harmer, S. F., D.Sc., F.R.S., *British Museum (Natural History), Cromwell Road, S.W.*	*C.*
1912	Hart, E. Tulk, M.D., *Totteridge, Dyke Road, Hove*	Ann.
1889	Harvey, T. H., *Cattedown, Plymouth*	Ann.
1888	Haselwood, J. E., 3, *Richmond Terrace, Brighton*	*C.*
1884	Haslam, Miss E. Rosa, *Ravenswood, Bolton*	£20
1884	Head, J. Merrick, F.R.G.S., J.P., *Pennsylvania Castle, Isle of Portland, Dorset*	Ann.
1884	Heape, Walter, F.R.S., 10, *King's Bench Walk, Temple, London, E.C.*	*C.*
1910	Hefford, A. E., B.Sc., 43, *Parliament Street, London, S.W.*	Ann.
*1908	Hepworth, Commander M. W. Campbell, C.B., R.N.R., *Meteorological Office, South Kensington, London, S.W.*	Ann.
*1884	Herdman, Prof. W. A., F.R.S., *The Zoology Department, The University, Liverpool*	Ann.
1913	Heron-Allen, E., F.L.S., F.R.M.S., F.G.S., 33, *Hamilton Terrace, London, N.W.*	Ann.
1884	Herschel, Col. J., R.E., F.R.S., *Observatory House, Slough, Berks.*	*C.*
1910	Hicks, F., *Zoological Laboratory, King's College, London, W.C.*	Ann.
1884	Hickson, Prof. Sydney J., M.A., D.Sc., F.R.S., *Ellesmere House, Wilenslow Road, Withington, Manchester*	Ann.
1910	Hill, Dr. Alex., *Royston, Herts*	Ann.

*1907 Hill, Prof. J. P., F.R.S., *The Zoological Laboratory, University College, London. W.C.* .... Ann.
1897 Hodgson, T. V., 54, *Kingsley Road, Plymouth* .... Ann.
*1905 Holt, E. W. L., *Department of Agriculture and Technical Instruction for Ireland (Fisheries Branch), Dublin* .... Ann.
1913 Howell, G. C. L., I.C.S., Director of Fisheries, *Punjab* .... Ann.
1909 Hoyle, W. E., M.A., D.Sc., *National Museum of Wales, City Hall, Cardiff* Ann.
1912 Huxley, J. S., *Balliol College, Oxford* .... Ann.

1888 Inskip, Capt. G. H., R.N., 22, *Torrington Place, Plymouth* .... Ann.

1885 Jackson, W. Hatchett, M.A., D.Sc., F.L.S., *Pen Wartha, Weston-super-Mare* .... Ann.
1910 Jenkinson, J. W., D.Sc., 27, *Polstead Road, Oxford* .... Ann.

1911 Kirkpatrick, R., *British Museum (Natural History), Cromwell Road, S.W.* Ann.

1897 Lanchester, W. F., B.A., 19, *Fernshaw Road, Chelsea, London, S.W.* ... C.
1885 Langley, Prof. J. N., F.R.S., *Trinity College, Cambridge* .... C.
1895 Lister, J. J., M.A., F.R.S., *St. John's College, Cambridge* .... Ann.
1910 Liversidge, Prof. A., F.R.S., *Fieldhead, George Road, Coombe Warren, Kingston, Surrey* .... Ann.
1910 Lucas, Keith, M.A., *Trinity College, Cambridge* .... Ann.

1885 Macalister, Prof. A., F.R.S., *St. John's College, Cambridge* .... Ann.
1884 MacAndrew, James J., *Lukesland, Ivybridge, South Devon* .... Ann.
*1910 MacBride, Prof. E. W., M.A., D.Sc., F.R.S., *Royal College of Science, South Kensington, S.W.* .... Ann.
1900 Macfie, J. W. Scott, *Rowton Hall, Chester* .... C.
1902 Major, Surgeon H. G. T., 24, *Beech House Road, Croydon* .... C.
1889 Makovski, Stanislaus, *Saffrons Corner, Eastbourne* .... Ann.
1885 Marr, J. E., M.A., F.R.S., *St. John's College, Cambridge* .... C.
1902 Martin, C. H., *The Hill, Abergavenny* .... Ann.
1906 Masterman, A. T., D.Sc., *Board of Agriculture and Fisheries (Fisheries Division), 43, Parliament Street, London, S.W.* .... Ann.
1910 Matthews, D. J., *The Laboratory, Plymouth* .... Ann.
1912 Matthews, Mrs. D. J., *The Laboratory, Plymouth* .... Ann.
*1912 Maurice, H. G., *Board of Agriculture and Fisheries, 43, Parliament Street, S.W.* .... Ann.
1910 McClean, W. N., 63, *Evelyn Gardens, South Kensington, S.W.* .... Ann.
1884 McIntosh, Prof. W. C., F.R.S., *Nevay Park, Meigle, N.B.* .... C.
1884 Michael, Albert D., *The Warren, Studland, nr. Wareham, Dorset* ...... C.
1909 Midgley, J. H., *Birstwith, Torquay* .... Ann.
1903 Mill, H. R., D.Sc., 62, *Camden Square, London, N.W.* .... Ann.
1899 Minchin, Prof. E. A., 4, *Tennyson Mansions, Cheyne Row, Chelsea, S.W.* Ann.
1905 Mitchell, P. Chalmers, D.Sc., F.R.S., Secretary Zoological Society, *Regent's Park, London, N.W.* .... Ann.
1906 Morford, Rev. Augustin, *The Friary, Saltash, Cornwall* .... Ann.
1910 Müller, Prof. Hugo, F.R.S., 13, *Park Square East, Regent's Park, London, N.W.* .... Ann.
†1896 Murray, Sir John, K.C.B., F.R.S., *Challenger Lodge, Wardie, Edinburgh* Ann.

1912 Newman, C. A., *Bramston House, Oundle* .... Ann.
†1884 Norman, Rev. A. M., M.A., D.C.L., F.R.S., *The Red House, Berkhamsted, Herts* .... Ann.

1911 Oldham, Chas., *Kelvin, Boxwell Road, Berkhamsted, Herts.* .... Ann.
1910 Orton, J. H., B.Sc., *The Laboratory, Plymouth* .... Ann.

1910 Pennell, Lieut. H., *Awliscombe, Honiton, Devon* .... Ann.
1906 Plymouth Corporation (Museum Committee) .... Ann.
1910 Plymouth Education Authority .... Ann.
1906 Port of Plymouth Incorporated Chamber of Commerce .... Ann.
1910 Porter, Horatio, 16, *Russell Square, London, W.C.* .... Ann.
1913 Potts, F. A., M.A., *Trinity Hall, Cambridge* .... C.
1910 Preston, H. B., F.Z.S., 53, *West Cromwell Road, London, S.W.* .... Ann.
1911 Purves, Miss, 5, *Holyrood Place, Plymouth* .... Ann.
1884 Pye-Smith, P. H., M.D., 48, *Brook Street, W.* .... C.

1893 Quintin, St. W. H., *Scampstone Hall, Rillington, Yorks* .... Ann.

1913 Raymond, Major G., 35, *Connaught Avenue, Mutley, Plymouth* .... Ann.
1892 Rüffer, M. A., M.D., *Conseil Sanitaire, Maritime et Quarentenaire, Alexandria, Egypt* .... Ann.

1911 Saunders, J. T., B.A., *Christ's College, Cambridge* .... Ann.
1888 Scharff, Robert F., Ph.D., *Science and Art Museum, Dublin* .... Ann.
1901 Schiller, F. W., *Butterhill, Stafford* .... Ann.
*1909 Schuster, Edgar, D.Sc., 110, *Banbury Road, Oxford* .... Ann.
1884 Sclater, W. L., *Odiham Priory, Winchfield, Hants* .... Ann.
1885 Scott, D. H., M.A., Ph.D., F.R.S., *East Oakley House, Oakley, Hants* .... C.
1903 Scott, S. D., *Boyne House, Cheltenham* .... Ann.
1888 Serpell, E. W., *Loughtonhurst, West Cliff Gardens, Bournemouth* £50
1900 Sexton, L. E., 3, *Queen Anne Terrace, Plymouth* .... Ann.
1904 Shaw, Joseph, K.C., *Bryanston Square, London, W.* £13
1885 Sheldon, Miss Lilian, *High Park, Bideford* .... Ann.
*1884 Shipley, Arthur E., M.A., F.R.S., *Christ's College, Cambridge*...*C. and* Ann., £5
1885 Sinclair, F. G., *Friday Hill, Chingford, Essex* .... C.
1891 Sinclair, William F., 102, *Cheyne Walk, Chelsea, S.W.* .... C.
1884 Skinners, the Worshipful Company of, *Skinners' Hall, E.C.* £42
1889 Slade, Rear-Admiral Sir E. J. W., K.C.I.E., K.C.V.O., 128, *Church Street, Campden Hill, London, W.* .... C.
*1910 Smith, Geoffrey W., *New College, Oxford* .... Ann.
1888 Spencer, Prof. W. Baldwin, M.A., F.R.S., *University of Victoria, Melbourne* Ann.
1907 Sprague, Thomas Bond, M.A., LL.D., 29, *Buckingham Terrace, Edinburgh* Ann.
1897 Straker, J., LL.M., F.Z.S., *Oxford and Cambridge Club, S.W.* .... C.

*1899 Thompson, Prof. D'Arcy W., C.B., *University College, Dundee* .... Ann
1890 Thompson, Sir H. F., Bart., 9, *Kensington Park Gardens, London, W.* Ann.
1884 Thornycroft, Sir John I., F.R.S., *Eyot Villa, Chiswick Mall* .... Ann.
1906 Tims, H. W. Marett, M.D., *Bedford College, Regent's Park, London, N.W.* Ann.
1903 Torquay Natural History Society, *Torquay* .... Ann.

*1897	Travers, J. A., *Tortington House, Arundel*	Ann.
1910	Travers, Miss R. C., *Tortington House, Arundel*	Ann.
1891	Vaughan, Henry	*C.*
1884	Walker, Alfred, O., *Ulcombe Place, Maidstone*	Ann.
1884	Walker, P. F., 36, *Prince's Gardens, S.W.*	Ann.
1910	Wallace, W., D.Sc., 43, *Parliament Street, London, S.W.*	Ann.
†1884	Walsingham, The Rt. Hon. Lord, F.R.S., *Merton Hall, Thetford*	£20
1912	Ward, Dr. Francis, 20, *Park Road, Ipswich*	Ann.
1906	Waterhouse, N. E., 3, *Fredericks Place, Old Jewry, London, E.C.*	Ann.
1909	Waters, Arthur W., F.L.S., *Alderley, McKinley Road, Bournemouth*	Ann.
1909	Watson, A. T., *Southwold, Tapton Crescent Road, Sheffield*	Ann.
1906	Weldon, Mrs., *Merton Lea, Oxford*	Ann.
1910	Willes, W. A., *Elmwood, Cranborne Road, Bournemouth*	Ann.
1900	Willey, A., D.Sc., F.R.S., *McGill University, Montreal, Canada*	Ann.
1908	Williamson, Lieut. H. A., R.N., *The Central Flying School, Upavon*	Ann.
1884	Wilson, Scott, B., *Heather Bank, Weybridge Heath*	*C.*
1913	Wise, W. H., 34, *George Street, Plymouth*	Ann.
1900	Wolfenden, R. N., M.D.	Ann.
1905	Woolf, M. Yeatman, *Wimpole House, Wimpole Street, London, W.*	Ann.
1898	Worth, R. H., 42, *George Street, Plymouth*	Ann.

IV.—Associate Members.

1889 Caux, J. W. de, *Great Yarmouth.*
1904 Donnison, F., *Deep Sea Fishing Co., Boston.*
1904 Edwards, W. C., *Mercantile Marine Office, St. Andrew's Dock, Hull.*
1904 Freeth, A. J., *Fish Quay, North Shields.*
1904 Hurrell, H. E., 25, *Regent Street, Yarmouth.*
1904 Inskip, H. E., Capt., R.N., *Harbour Master's Office, Ramsgate.*
1904 Johnson, A., *Fishmongers' Company, Billingsgate Market, London, E.C.*
1889 Olsen, O. T., F.L.S., F.R.G.S., *Fish Dock Road, Great Grimsby.*
1904 Patterson, Arthur, *Ibis House, Great Yarmouth.*
1889 Ridge, B. J., *Newlyn, Penzance.*
1901 Sanders, W. J., *Rockvall, Brixham.*
1889 Sinel, Joseph, 8, *Springfield Cottages, Springfield Road, Jersey, C.I.*
1890 Spencer, R. L., *L. and N.W. Depôt, Guernsey.*
1890 Wells, W., *The Aquarium, Brighton.*

List of Publications Recording the Results of Researches carried out under the Auspices of the Marine Biological Association of the United Kingdom in their Laboratory at Plymouth or on the North Sea Coast from 1886–1913.

THE following list has been classified, so far as practicable, according to subjects, in order that it may be useful for purposes of reference. The list does not include publications recording the results of observations made on material supplied by the Association to workers in different parts of the country, of which a considerable amount is sent out each year.

In attempting to distinguish between economic and more purely scientific publications considerable difficulty has been experienced; indeed such a distinction is in reality impossible, since all researches bearing on the distribution and habits of marine life of any kind have a more or less direct bearing on fishery problems. All papers dealing with the distribution, habits, and young stages of fishes have been included in the economic division, whether the fishes are themselves marketable or not.

September, 1913.

Economic Publications.

FISHES.

1. GENERAL.

The Natural History of the Marketable Marine Fishes of the British Islands. Prepared by order of the Council of the Marine Biological Association especially for the use of those interested in the Sea-Fishing Industries. By J. T. Cunningham, M.A. With a preface by E. Ray Lankester, M.A., LL.D., F.R.S. London: Macmillan and Co., Ltd., 1896.

Eggs and Larvæ.

The Ovaries of Fishes. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iii. 1893–95, p. 154.

On the Histology of the Ovary and of the Ovarian Ova in certain Marine Fishes. By J. T. Cunningham, M.A. Quart. Journ. Micr. Sci. XL. 1897, p. 101.

A Contribution to the Knowledge of the Ovary and Intra-ovarian Egg in Teleosteans (with Plates XI. and XII.). By W. L. Calderwood. Journ. M.B.A. N.S. ii. 1891–92, p. 298.

Observations on Ovarian Ova and Follicles in certain Teleostean and Elasmobranch Fishes. By W. Wallace, M.A. Quart. Journ. Micr. Sci., vol. xlvii. p. 161.

A Record of the Teleostean Eggs and Larvæ observed at Plymouth in 1897. By E. W. L. Holt and S. D. Scott, B.A. Journ. M.B.A. N.S. v. 1897–99, p. 156.

Studies on the Reproduction and Development of Teleostean Fishes occurring in the neighbourhood of Plymouth (with Plates I.–VI.). By J. T. Cunningham, M.A. Journ. M.B.A. N.S. i. 1889–90, p. 10.

On Some Larval Stages of Fishes (with Plates III. and IV.). By J. T. Cunningham, M.A. Journ. M.B.A. N.S. ii. 1891–92, p. 68.

On Some Disputed Points in Teleostean Embryology. By J. T. Cunningham, M.A. Ann. and Mag. Nat. Hist. 1891.

Recherches sur la Reproduction des Poissons osseux. Par E. W. L. Holt. Ann. Mus. Hist. Nat. Marseille, v., 1899.

Preliminary notes on the Reproduction of Teleostean Fishes in the South-Western District. By E. W. L. Holt. Journ. M.B.A. N.S. v. 1897–99, p. 41.

Notes on the Reproduction of Teleostean Fishes in the South-Western District. By E. W. L. Holt and L. W. Byrne, B.A. Journ. M.B.A. N.S. v. 1897–99, p. 333.

Report on the Eggs and Larvæ of Teleostean Fishes observed at Plymouth in the Spring of 1902. By F. Balfour Browne, M.A. Journ. M.B.A. vi. 1903, p. 598.

Notes on the Reproduction of Teleostean Fishes in the South-Western District. By E. W. L. Holt. Journ. M.B.A. N.S. v. 1897–99, p. 107.

Report on a Collection of Very Young Fishes obtained by Dr. G. H. Fowler in the Faeroë Channel. By E. W. L. Holt. Proceed. Zool. Soc., London. 1898, p. 550.

Report on the Results of the Fish-Egg Cruise made by the s.s. *Huxley* in June, 1909. By H. J. Buchanan Wollaston. Internat. Fish. Investigations. Mar. Biol. Assoc. Report III. 1906–08 (Cd. 5546). 1911, p. 207.

Notes on Teleostean Ova and Larvæ observed at Plymouth in Spring and Summer, 1909. By A. E. Hefford, B.SC. Journ. M.B.A. N.S. ix. 1910–13, p. 1.

Age, Growth, and Maturity.

The Rate of Growth of some Sea Fishes and their Distribution at Different Ages. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. ii. 1891–92, p. 95.

On the rate of Growth of some Sea Fishes and the Age and Size at which they begin to breed. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. ii. 1891–92, p. 222.

Report on the Probable Ages of Young Fish collected by Mr. Holt in the North Sea. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. ii. 1891–92, p. 344.

On the Relation of Size to Sexual Maturity in Pleuronectids. (North Sea Investigations.) By E. W. L. Holt. Journ. M.B.A. N.S. ii. 1891–92, p. 363.

On the Relation of Size to Sexual Maturity in Round-fish. (North Sea Investigations.) By E. W. L. Holt. Journ. M.B.A. N.S. iii. 1893–95, p. 78.

On the Relations of the Generative Organs and of the Sexes in some Fishes. (North Sea Investigations.) By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iv. 1895–97, p. 28.

Hybridism in Marine Fishes. By H. M. Kyle, D.SC. Journ. M.B.A. vi. 1903, p. 623.

Destruction of Immature Fish.

An Examination of the Present State of the Grimsby Trawl Fishery, with especial reference to the Destruction of Immature Fish. By E. W. L. Holt. Journ. M.B.A. N.S. iii. 1893–95, p. 339. (Cf. N.S. iv. 1895–97, p. 410.) Also issued as a separate publication.

Destruction of Immature Fish. By G. C. Bourne, M.A. Journ. M.B.A. N.S. i. 1889–90, p. 153.

On the Destruction of Immature Fish in the North Sea. Remedial Measures. (North Sea Investigations.) By E. W. L. Holt. Journ. M.B.A. N.S. ii. 1891–92, pp. 380, 388.

The Immature Fish Question. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iii. 1893–95, p. 54.

Growth and Distribution of Young Food-Fishes. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iii. 1893–95, p. 272.

On the Destruction of Immature Fish in the North Sea. (North Sea Investigations.) By E. W. L. Holt. Journ. M.B.A. N.S. iii. 1893–95, pp. 81, 123, 169, 288.

Statistics of Small Fish landed at Grimsby. (North Sea Investigations.) By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iv. 1895–97, p. 10.

Fish and Fishing Grounds.

The Impoverishment of the Sea. By W. Garstang, M.A. Journ. M.B.A. N.S. vi. 1900, p. 1.

Notes on the Fishing Industry of Plymouth. By Walter Heape, M.A. Journ. M.B.A. Old Series. No. 1. 1887, p. 45.

Monthly Reports on the Fishing in the neighbourhood of Plymouth (with 8 charts). By W. L. Calderwood. Journ. M.B.A. N.S. ii. 1891–92, p. 277 and p. 394. N.S. iii. 1893–95, p. 107.

Preliminary Note on Trawling Experiments in certain Bays on the South Coast of Devon. By F. B. Stead, B.A. Journ. M.B.A. N.S. iv. 1895–97, p. 90.

Report on Trawling in Bays on the South Coast of Devon. By E. W. L. Holt. Journ. M.B.A. N.S. v. 1897–99, p. 296.

Report on Trawling and other Investigations carried out in the Bays on the South-east Coast of Devon during 1901 and 1902. Prepared for the information of the Devon Sea Fisheries Committee by Walter Garstang, M.A. Journ. M.B.A. N.S. vi. 1903, p. 435.

Notes on Rare or Interesting Specimens (*Clupea alosa*, *Auxis Rochei*, *Thynnus thynnus*, *Myliobatis aquila*). By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iii. 1893–95, p. 274.

North Sea Investigations. Preliminary. By E. W. L. Holt. Journ. M.B.A. N.S. ii. 1891–92, p. 216.

On the Territorial Fishing Ground of Scarborough and its Neighbourhood. (North Sea Investigations.) By E. W. L. Holt. Journ. M.B.A. N.S. iii. 1893–95, p. 176.

On the Iceland Trawl Fishery, with some Remarks on the History of the North Sea Trawling Grounds. (North Sea Investigations.) By E. W. L. Holt. Journ. M.B.A. N.S. iii. 1893–95, p. 129.

Notes on a Fishing Voyage to the Barents Sea in August, 1907. By George T. Atkinson. Journ. M.B.A. N.S. viii. 1907–10, p. 71.

Two Trips to the Eastern Grounds. (North Sea Investigations.) By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iv. 1895–97, p. 33.

Notes on the General Course of the Fishing. (North Sea Investigations.) By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iv. 1895–97, p. 12.

Observations at Sea and in the Markets—Grimsby, Scarborough, Hull, Lowestoft. (North Sea Investigations.) By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iv. 1895–97, p. 108.

Account of a Voyage in the Smack *Albert* to the Newfoundland Fishing Banks. By W. T. Grenfell, M.R.C.S. Journ. M.B.A. N.S. iii. 1893–95, p. 143.

The Fishes collected by the *Huxley* from the North Side of the Bay of Biscay in August, 1906. By L. W. Byrne. Journ. M.B.A. N.S. viii. 1907–10, p. 1.

Causes of the Observed Distribution of Fish in the North Sea. (North Sea Investigations.) By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iv. 1895–97, p. 133.

Physical and Biological Conditions in the North Sea. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iv. 1895–97, p. 233.

General Report on the Fishery Investigations. By Walter Garstang, M.A. Internat. Fish. Investigations. Mar. Biol. Assoc. Report I. 1902–03 (Cd. 2670). 1905, p. 1.

Report on Experiments with Marked Fish during 1902–03. By Walter Garstang, M.A. Internat. Fish. Investigations, Mar. Biol. Assoc. Report I. 1902–03 (Cd. 2670). 1905, p. 13.

Report on the Trawling Investigations, 1902–03, with especial reference to the distribution of the Plaice. By Walter Garstang, M.A. Internat. Fish. Investigations, Mar. Biol. Assoc. Report I. 1902–03 (Cd. 2670). 1905, p. 67.

Trawling Investigations, 1904–05. I. Particulars of Trawling Stations of s.s. *Huxley*. II. Detailed Measurements of Plaice caught at each haul of the Commercial Trawls (s.s. *Huxley*). III. Summaries of hauls made by s.s. *Huxley*, distinguishing the sizes of fish in 10-centimetre groups. Internat. Fish. Investigations. Mar. Biol. Assoc. Report II., Part 2. 1904–05 (Cd. 4641). 1909, p. 114.

Trawling Investigations, 1906–09. Internat. Fish. Investigations. Mar. Biol. Assoc. Report IV. 1909 (Cd. 6125). 1912, p. 394.

Covered Net Experiments. By R. A. Todd, B.SC. Internat. Fish. Investigations. Mar. Biol. Assoc. Report III. 1906–08 (Cd. 5546). 1911, p. 177.

Report on the Lowestoft Sailing Trawler Records, 1903–06. By Rosa M. Lee, M.A. Internat. Fish. Investigations. Mar. Biol. Assoc. Report II., Part 2. 1904–05 (Cd. 4641). 1909, p. 89.

Comparative Notes on various Trawler Catches in the North Sea, including some Steam Trawler Records for 1903 and 1905. By Rosa M. Lee, M.A. Internat. Fish. Investigations. Mar. Biol. Assoc. Report IV. 1909 (Cd. 6125). 1912, p. 291.

Report on the Grimsby Steam Trawler Records, 1904–07. By Rosa M. Lee, M.A. Internat. Fish. Investigations. Mar. Biol. Assoc. Report III. 1906–08 (Cd. 5546). 1911, p. 1.

Food and Feeding of Fishes.

Report on the Food of Fishes collected during 1903. By R. A. Todd, B.SC. Internat. Fish. Investigations. Mar. Biol. Assoc. Report I. 1902–03 (Cd. 2670). 1905, p. 227.

Second Report on the Food of Fishes (North Sea, 1904–1905). By R. A. Todd, B.SC. Internat. Fish. Investigations. Mar. Biol. Assoc. Report II., Part 1. 1904–05 (Cd. 3837). 1907, p. 49.

The Sense-Organs and Perceptions of Fishes, with Remarks on the Supply of Bait (with Plate XX.). By W. Bateson, M.A. Journ. M.B.A. N.S. i. 1889–90, p. 225.

Experiments on the Production of Artificial Baits. By Frank Hughes. Journ. M.B.A. N.S. ii. 1891–92, pp. 91 and 220.

Notes on How Fish Find Food. (Report on the occupation of Table.) By Gregg Wilson, M.A., B.SC. Report Brit. Assoc., 1893, p. 548.

Notes on the Invertebrate Fauna and Fish-food of the Bays between the Start and Exmouth. By R. A. Todd, B.SC. Journ. M.B.A. N.S. vi. 1903, p. 541.

Rearing Experiments.

Recent Experiments Relating to the Growth and Rearing of Food-fish at the Laboratory. ii. The Rearing of Larval Fish. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. i. 1889–90, p. 370.

Breeding of Fish in the Aquarium. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. ii. 1891–92, p. 195.

Experiments on the Rearing of Fish-Larvæ in the Season of 1894. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iii. 1893–95, p. 206.

Growth of Fishes in the Aquarium. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iii. 1893–95, p. 167.

Rearing of Fish-Larvæ. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iii. 1893–95, p. 168.

Experiments on Sea-Fish Culture. By W. Garstang, M.A. Report Brit. Assoc., 1899.

Preliminary Experiments on the Rearing of Sea-Fish Larvæ. By W. Garstang, M.A. Journ. M.B.A. N.S. vi. 1900, p. 70.

On the First Successful Experiment with Importation of European Sea Fishes to Australian Waters. By H. C. Dannevig. Fisheries of New South Wales. Annual Report for 1902, II.

Diseases of Fish.

Some Notes on Parasitic and other Diseases of Fish. By G. H. Drew. Parasitology, vol. ii. 1909, p. 193.

Some Notes on Parasitic and other Diseases of Fish. Second Series. By G. H. Drew, B.A. Parasitology, vol. iii. 1910, p. 54.

Some Cases of New Growths in Fish. By G. H. Drew, B.A. Journ. M.B.A. N.S. ix. 1910–13, p. 281.

A List of Blood Parasites of Sea Fish taken at Plymouth. By Herbert Henry, M.D. Journ. M.B.A. N.S. ix. 1910–13, p. 570.

Note on Abnormal Pigmentation of a Whiting infected by *Trematode larvæ*. By Prof. F. W. Gamble, F.R.S., and G. H. Drew, B.A. Journ. M.B.A. N.S. ix. 1910–13, p. 243.

Miscellaneous.

Modes in which Fish are affected by Artificial Light. By W. Bateson, M.A. Journ. M.B.A. N.S. i. 1889–90, p. 216.

The Amount of Fat in Different Fishes. By F. Hughes. Journ. M.B.A. N.S. ii. 1891–92, p. 196.

The Vernacular Names of Common Fishes. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. i. 1889–90, p. 92.

The Regulations of the Local Sea Fisheries Committees in England and Wales. By E. J. Allen, B.SC. Journ. M.B.A. N.S. iv. 1895–97, p. 386.

Fishing Nets, with special reference to the Otter Trawl. By H. M. Kyle, M.A., D.SC. Journ. M.B.A. N.S. vi. 1903, p. 562.

2. THE EEL FAMILY.

The Breeding of the Conger. By J. T. Cunningham, M.A. Journ. M.B.A. Old Series. No. 2. 1888, p. 245.

On the Reproduction and Development of the Conger. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. ii. 1891–92, p. 16.

On a Specimen of *Leptocephalus Morrisii*. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iv. 1895–97, p. 73.

Sudden Colour-changes in Conger. By W. Bateson, M.A. Journ. M.B.A. N.S. i. 1889–90, p. 214.

The Larva of the Eel. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iii. 1893–95, p. 278.

The Reproductive Maturity of the Common Eel. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iv. 1895–97, p. 87.

Eels and Sticklebacks in Sea-water. By W. L. Calderwood. Journ. M.B.A. N.S. ii. 1891–92, p. 77.

Note on *Muraena helena*, Linn. By E. W. L. Holt. Journ. M.B.A. N.S. v. 1897–99, p. 91.

3. THE HERRING FAMILY.

Anchovies in the English Channel (with an illustration in the text). By J. T. Cunningham, M.A. Journ. M.B.A. N.S. i. 1889–90, p. 328.

Probable Relation between Temperature and the Annual Catch of Anchovies in the Schelde District (with Plate XXIV.). By G. H. Fowler, B.A., PH.D. Journ. M.B.A. N.S. i. 1889–90, p. 340.

Experiments on the Relative Abundance of Anchovies off the South Coast of England. By W. L. Calderwood. Journ. M.B.A. N.S. ii. 1891–92, p. 268.

The Migration of the Anchovy. By J. T. Cunningham, M.A. Journn. M.B.A. N.S. iii. 1893–95, p. 300.

Ichthyological Contributions. iv. Growth of Young Herring in the Thames Estuary. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. ii. 1891–92, p. 330.

On the Occurrence of Large Numbers of Larval Herrings at the Surface. By Matthias Dunn. Journ. M.B.A. N.S. v. 1897–99, p. 184.

Notes on the Herring, Long-line and Pilchard Fisheries of Plymouth during the Winter 1889–90. By W. Roach. Journ. M.B.A. N.S. i. 1889–90, p. 382.

Notes on Herring, Long-line and Pilchard Fisheries of Plymouth. By W. Roach. Journ. M.B.A. N.S. ii. 1891–92, p. 180.

The Spawn of the Pilchard. By J. T. Cunningham, M.A. Journ. M.B.A. Old Series, No. 2. 1888, p. 247.

The Reproduction and Growth of the Pilchard (with Plate X.). By J. T. Cunningham, M.A. Journ. M.B.A. N.S. ii. 1891–92, p. 151.

Year-old Pilchards. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. ii. 1891–92, p. 398.

The Life History of the Pilchard. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iii. 1893–95, p. 148.

4. The Salmon Family.

The Great Silver Smelt, *Argentina silus*, Nilsson, an addition to the List of British Fishes. By E. W. L. Holt. Journ. M.B.A. N.S. v. 1897–99, p. 341.

Grayling and Loch Leven Trout in Salt Water. By W. L. Calderwood. Journ. M.B.A. N.S. v. 1891–92, p. 76.

On an Experiment in the Keeping of Salmon (*Salmo salar*) at the Plymouth Laboratory. By L. R. Crawshay, M.A. Journ. M.B.A. N.S. viii. 1907–10, p. 303.

5. Flat-fish Family.

Diagnostic characters in Flat-fishes. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. v. 1893–95, p. 247.

The Development of the Egg in Flat-fishes and Pipe-fishes. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iii. 1893–95, p. 258.

A Treatise on the Common Sole (*Solea vulgaris*), considered both as an organism and as a commodity. Prepared for the Marine Biological Association of the United Kingdom. By J. T. Cunningham, M.A., Plymouth. Published by the Association. 1890 (4to, pp. 147, with eighteen plates).

Reproductive Organs of the Common Sole. By J. T. Cunningham, M.A. Journ. M.B.A. Old Series, No. 2. 1888, p. 248.

Ichthyological Contributions. ii. On a Stage in the Metamorphosis of Solea. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. ii. 1891–92, p. 327.

Report on the Spawning of the Common Sole in the Aquarium of the Marine Biological Association's Laboratory during April and May, 1895. By G. W. Butler, B.A. Journ. M.B.A. N.S. iv. 1895–97, p. 3.

The Size of Mature Plaice, Turbot, and Brill on different Fishing Grounds. (North Sea Investigations.) By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iv. 1895–97, p. 97.

On the Peculiarities of Plaice from different Fishing Grounds. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iv. 1895–97, p. 315.

Observations on the Natural History of Plaice. (North Sea Investigations.) By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iv. 1895–97, p. 15.

Proposed Restrictions on the Landing of undersized Plaice in the light of the New Evidence. (North Sea Investigations.) By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iv. 1895–97, p. 138.

On a Dwarf Variety of the Plaice, with some Remarks on the Occasional Ciliation of the Scales in that Species. (North Sea Investigations.) By E. W. L. Holt. Journ. M.B.A. N.S. iii. 1893–95, p. 194.

A Piebald Plaice. By J. T. Cunningham, M.A. Journ. M.B.A. N.S. iii. 1893–95, p. 271.

Variation und Asymetrie bei Pleuronectes flesus L. By G. Duncker. Wissen. Meeresuntersuch. ii. 1900, p. 333.

The Periodic Growth of Scales in Gadidæ and Pleuronectidæ as an Index of Age. By J. S. Thomson. Journ. M.B.A. N.S. vi. 1902, p. 373.

Experiments in the Transplantation of Small Plaice to the Dogger Bank. By Walter Garstang, M.A. Internat. Fish. Investigations. Mar. Biol. Assoc. Report I. 1902–03 (Cd. 2670). 1905, p. 45.

Preliminary Investigations on the Age and Growth-Rate of Plaice. By William Wallace, D.SC. Internat. Fish. Investigations. Mar. Biol. Assoc. Report I. 1902–03 (Cd. 2670). 1905, p. 199.

An Experiment in the Transplantation of Plaice from the Barents Sea ("White Sea") to the North Sea. By George T. Atkinson. Journ. M.B.A. N.S. viii. 1907–10, p. 502.

Report on the Age and Growth-Rate of Plaice in the Southern North Sea as determined by the Investigation of Otoliths. By William Wallace, D.SC. Internat. Fish. Investigations. Mar. Biol. Assoc. Report II., Part 1. 1904–05 (Cd. 3837). 1907, p. 1.

Report on the Vitality of Trawl-caught Plaice. By J. O. Borley, M.A. Internat. Fish. Investigations. Mar. Biol. Assoc. Report II., Part 2. 1904–05 (Cd. 4641). 1909, p. 1.

Report on the Size and Age of Plaice at Maturity in the North Sea and

English Channel. By William Wallace, D.SC. Internat. Fish. Investigations. Mar. Biol. Assoc. Report II., Part 2. 1904–05 (Cd. 4641). 1909, p. 51.

The Distribution of the Plaice in the North Sea, Skagerak and Kattegat, according to size, age, and frequency. By Walter Garstang. Conseil Perm. Internat. Explor. Mer. Rapp. et Proc. Verb., vol. xi. 1909, p. 65.

The Proportionate Distribution of the Sexes of Plaice in the North Sea. By A. E. Hefford. Conseil Perm. Internat. Explor. Mer. Rapp. et Proc. Verb., vol. xi. 1909, p. 135.

Further Report on the Age and Growth-Rate of Plaice in the North Sea and English Channel, as determined by the Investigation of Otoliths. By William Wallace, D.SC. Internat. Fish. Investigations. Mar. Biol. Assoc. Report III. 1906–08 (Cd. 5546). 1911, p. 109.

Report on the Experimental Transplantation of Plaice to the Dogger Bank carried out by the Marine Biological Association in the years 1904–08. By J. O. Borley, M.A. Internat. Fish. Investigations. Mar. Biol. Assoc. Report IV. 1909 (Cd. 6125). 1912, p. 1.

A Comparison of the Condition of the Plaice of Different Regions as to Weight. By J. O. Borley, M.A. Internat. Fish. Investigations. Mar. Biol. Assoc. Report IV. 1909 (Cd. 6125). 1912, p. 81.

Report on Plaice Transplantation Experiments to Various Fishing Grounds in the North Sea. By Rosa M. Lee, M.A., and George T. Atkinson. Internat. Fish. Investigations. Mar. Biol. Assoc. Report IV. 1909 (Cd. 6125). 1912, p. 107.

Report on Experiments with Marked Plaice during 1904 and 1905. By Walter Garstang, M.A., D.SC. Internat. Fish. Investigations. Mar. Biol. Assoc. Report IV. 1909 (Cd. 6125). 1912, p. 153.

Report on the English Plaice Marking Experiments, 1906–08. By George T. Atkinson. Internat. Fish. Investigations. Mar. Biol. Assoc. Report IV. 1909 (Cd. 6125). 1912, p. 225.

Note on *Pleuronectes microcephalus,* Donov. By E. W. L. Holt. Journ. M.B.A. N.S. iii. 1893–95, p. 121.

Rhombus maximus, Linn. (The Turbot.) By E. W. L. Holt. Journ. M.B.A. N.S. ii. 1891–92, p. 399.

Note on some Supposed Hybrids between the Turbot and the Brill. (North Sea Investigations.) By E. W. L. Holt. Journ. M.B.A. N.S. iii. 1893–95, p. 292.

Note on *Phrynorhombus unimaculatus,* Risso. By E. W. L. Holt. Journ. M.B.A. N.S. v. 1897-99, p. 343.

Hippoglossus vulgaris, Linn. (The Halibut.) By E. W. L. Holt. Journ. M.B.A. N.S. ii. 1891–92, p. 399.

On Secondary Sexual Characters in *Arnoglossus.* By J. T. Cunningham, M.A. Proceed. Zool. Soc. 1890, p. 540.

Note on *Arnoglossus laterna*, Walb. By E. W. L. Holt. Journ. M.B.A. N.S. ii. 1891–92, p. 283.

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Par

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Avec 6 Figures dans le Texte.

C'EST surtout pour étudier le développement post-embryonnaire de la Langouste commune (*Palinurus vulgaris* Latr.) que je me suis rendu au Laboratoire de Plymouth. L'endroit me semblait excellent parce que la Langouste n'est pas rare près des côtes dans les eaux du Devonshire et de la Cornouaille, parce qu'elle est principalement fréquente sur les fonds rocheux au-dessus desquels se dresse le phare d'Eddystone, aussi enfin, parce que le Laboratoire de Plymouth est très bien installé, avec un bateau, l'*Oithona*, qui peut se rendre en mer chaque jour et effectuer les pêches les plus diverses.

Car il fallait pêcher souvent et à toutes profondeurs pour atteindre le but que je m'étais fixé, et ce but n'était rien moins que de découvrir les stades jusqu'alors inconnus du développement de notre Langouste. Depuis les observations de Couch (1857, 25) justifiées par Gerbe (1858, 547) et par Dohrn (1870), mais à tort contestées par Sp. Bate (1868), on sait que le *P. vulgaris* sort de l'œuf sous une forme larvaire foliacée, hyaline, aplatie dans le sens dorso-ventral, que les anciens zoologistes avaient appelée *phyllosome* et tenaient pour un genre spécial de Crustacés décapodes. On savait aussi, depuis les recherches de Claus (1863), que le phyllosome acquiert progressivement des appendices à mesure qu'il se développe, qu'il peut atteindre une longueur de 21 mm., et qu'il garde jusque dans sa plus grande taille les caractères généraux qui lui sont propres et qui en font un organisme essentiellement pélagique. Mais quelle est la série des stades présentés par le phyllosome depuis la sortie de l'œuf jusqu'au moment où il acquiert la forme longue, trapue, et rétrécie des Decapodes normaux ? et comment s'effectue le passage à cette forme ? Autant de questions qu'il fallait se poser et que personne encore n'avait pu résoudre. A vrai dire, depuis les belles recherches de M. Boas (1881) récemment confirmées par M. Calman (1909), on était en droit de croire que le passage du phyllosome à la forme définitive s'effectue par le moyen d'un "stade natant" désigné jadis par M. Ortmann (1897) sous le nom de *puerulus* et considéré par cet auteur comme un genre autonome de Palinurien. J'ai moi-même apporté ma contribution (1912) aux travaux de ces auteurs et je connais actuellement le puerulus supposé d'une dizaine d'espèces de Langoustes. Mais ces Langoustes sont toutes exotiques, et d'ailleurs, c'est par une hypothèse rationnelle, mais non à la suite d'une observation directe, que l'on s'accorde à voir dans le puerulus le stade intermédiaire qui conduit du phyllosome à l'état de Langouste parfaite. Il convenait par suite de justifier les suppositions de M. Boas et de chercher à connaître tous les stades évolutifs ainsi que le puerulus de l'espèce localisée dans nos mers. Il fallait aussi chercher l'habitat des puerulus ; car ces organismes, au contraire des phyllosomes, sont d'une rareté extrême, et c'est tout au plus si l'on en possède une trentaine d'exemplaires, pour la totalité du groupe des Palinuriers.

La saison d'été m'a paru plus propre que toute autre à la solution de ces problèmes, car c'est dans la seconde quinzaine de juin et au début de juillet que M. Cunningham (1891–92) captura autour du phare d'Eddystone les premiers stades larvaires du *P. vulgaris*. Mon savant prédécesseur a très bien décrit et figuré ces stades, mais, peu favorisé par le temps, il n'a pu en obtenir que deux, et les pêches faites dans la suite ont été infructueuses, alors qu'elles auraient dû lui procurer la capture des stades plus âgés. C'est dans l'espoir d'obtenir ces stades que je me suis installé à Plymouth du 15 juillet au 1er septembre. Le bref exposé qu'on va lire montrera que le moment était bien choisi ; j'ajouterai, d'ailleurs, que je fus étrangement favorisé par une saison des plus propices.

I. STADES PHYLLOSOMES DE LA LANGOUSTE COMMUNE.

Je vais indiquer tout d'abord les stades phyllosomes obtenus par l'*Oithona* au cours decet te saison de pêches. L'étude n'en est pas encore achevée et c'est provisoirement que je les classe en série de la manière suivante :

Stade 1 (3 mm. environ). Antennules et antennes presque indivises, de longueur à peu près égale. Le bouclier céphalique atteint à peine la base des maxillipèdes postérieurs (*mxp. 3*) ; exopodite des péréiopodes 3 (*p. 3*) dépourvu de soies, péréiopodes des deux paires suivantes (*p. 4*, *p. 5*) à l'état de bourgeons très courts. Abdomen sans appendices visibles et sans articulations bien distinctes en dehors du telson. Ce stade a été parfaitement figuré par M. Cunningham dans la première figure de son mémoire ; il est celui que présente le phyllosome à sa sortie de l'œuf.

Stade 2 (4 à 5 mm.). Un court bourgeon représente le fouet interne des antennules ; *p. 5* et surtout *p. 4* plus allongés qu'au stade précédent ; des uropodes légèrement échancrés au bout et atteignant au plus le milieu du telson, qui est tronqué en arrière ; la segmentation de l'abdomen encore très vague.

Stade 3 (6 à 8 mm.). La portion pédonculaire des antennules est divisée en deux articles, le fouet interne égale environ un tiers du fouet externe. Le pédoncule des antennes est indivise, et un peu plus court que le fouet, qui est également indivise. Le céphalon recouvre la base de *mxp. 3* ; *mxp. 2* avec un bourgeon exopodial. Des soies à l'exopodite de *p. 3*, *p. 4* avec un exopodite nu. Des pléopodes representés par un bourgeon aplati et échancré en arrière ; uropodes plus longs qu'au stade 2 et profondément échancrés en deux rames ; segmentation de l'abdomen bien distincte, surtout dans les régions épimérales. C'est le dernier stade observé par M. Cunningham, qui l'a bien décrit et fort exactement figuré.

Stade 4 (9 mm.). Le pédoncule antennulaire commence à montrer une division en 3 articles. Il y a déjà quelques soies sur l'exopodite de *p. 4* ; cette patte à peu près aussi longue que l'abdomen. Les pléopodes sont nettement biramés ; le telson est arrondi sur son bout distal et légèrement plus long que les uropodes dont l'exopodite présente une très nette échancrure externe.

Stade 5 (10 mm.). Le pédoncule antennulaire est nettement divisé en 3 articles ; les antennes sont un peu plus longues que les antennules. L'exopodite de *p. 4* atteint presque le bout de l'endopodite ou, tout au moins, en dépasse le milieu.

Stade 6 (12–13 mm.). Le fouet interne des antennules égale à peu près la moitié du fouet externe ; le fouet antennaire égale une fois et demie la longueur de son pédoncule. L'exopodite de *mxp. 2* atteint l'extrémité distale de l'article suivant ; *p. 5* arrive à peine à la base des uropodes ; les soies de p. *4* bien développées.

Stade 7 (14–15 mm.). Le fouet antennaire égale près de deux fois la longueur du pédoncule ; *mxp. 1* est déjà long ; l'exopodite de *mxp. 2* dépasse l'extrémité distale de l'article suivant. Ce stade a été assez bien figuré par Claus (1863, Taf. XXVI, fig. 7) et avec quelques erreurs par J. Couch (1858).

Stade 8. N'a pas encore été trouvé.

Stade 9 (20–21 mm.). (Fig. 1.) Le fouet interne des antennules égale presque le fouet externe ; les antennes sont à peu près aussi longues que le céphalo-thorax, et leur fouet, où l'on voit déjà des traces de segmentation, égale environ trois fois la longueur du pédoncule. L'exopodite des mâchoires est bien développé. Exopodite de *mxp. 1* long et formé de 2 articles, toutes les autres parties de l'appendice (sauf probablement l'épipodite) sont bien indiquées mais réduites ; exopodite de *mxp. 2* à peu près aussi long que l'endopodite, mais dépourvu de soies. Appareil branchial formé des mêmes parties que celui de l'adulte, mais les épipodites de *mxp. 1* et *mxp. 2* font probablement défaut ; le céphalon recouvre la base de *p. 1*. Les épimères abdominaux sont toujours arrondis, les pléopodes ont un pédoncule très net. Les pédoncules oculaires, grâce à leur tigelle fort longue, atteignent le bout distal des antennules et dépassent le pédoncule des antennes. C'est le dernier stade observé jusqu'ici ; Claus en a donné la description et la figure (1863, Taf. XXVI, fig. 8) ; il a été passablement représenté par Spence Bate (1863, fig. 1).

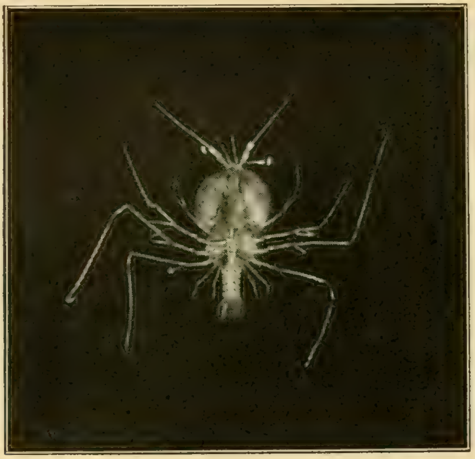

FIG. 1.—Phyllosome de *P. vulgaris* à l'avant-dernier stade (stade 9) capturé près du phare d'Eddystone. Photographié au Laboratoire d'entomologie du Muséum par M. Boyer. (Cliché communiqué par "Science et Vie".) Grandeur naturelle.

Stade 10 (20–21 mm.). *Ce stade très intéressant était resté inconnu, non seulement dans notre Langouste commune, mais chez tous les Palinuridés.* On en trouvera ci-contre la figure (fig. 2). Ce qui le distingue essentiellement, c'est la structure de l'abdomen qui se rapproche déjà beaucoup de celle de la Langouste adulte ; car le telson présente deux

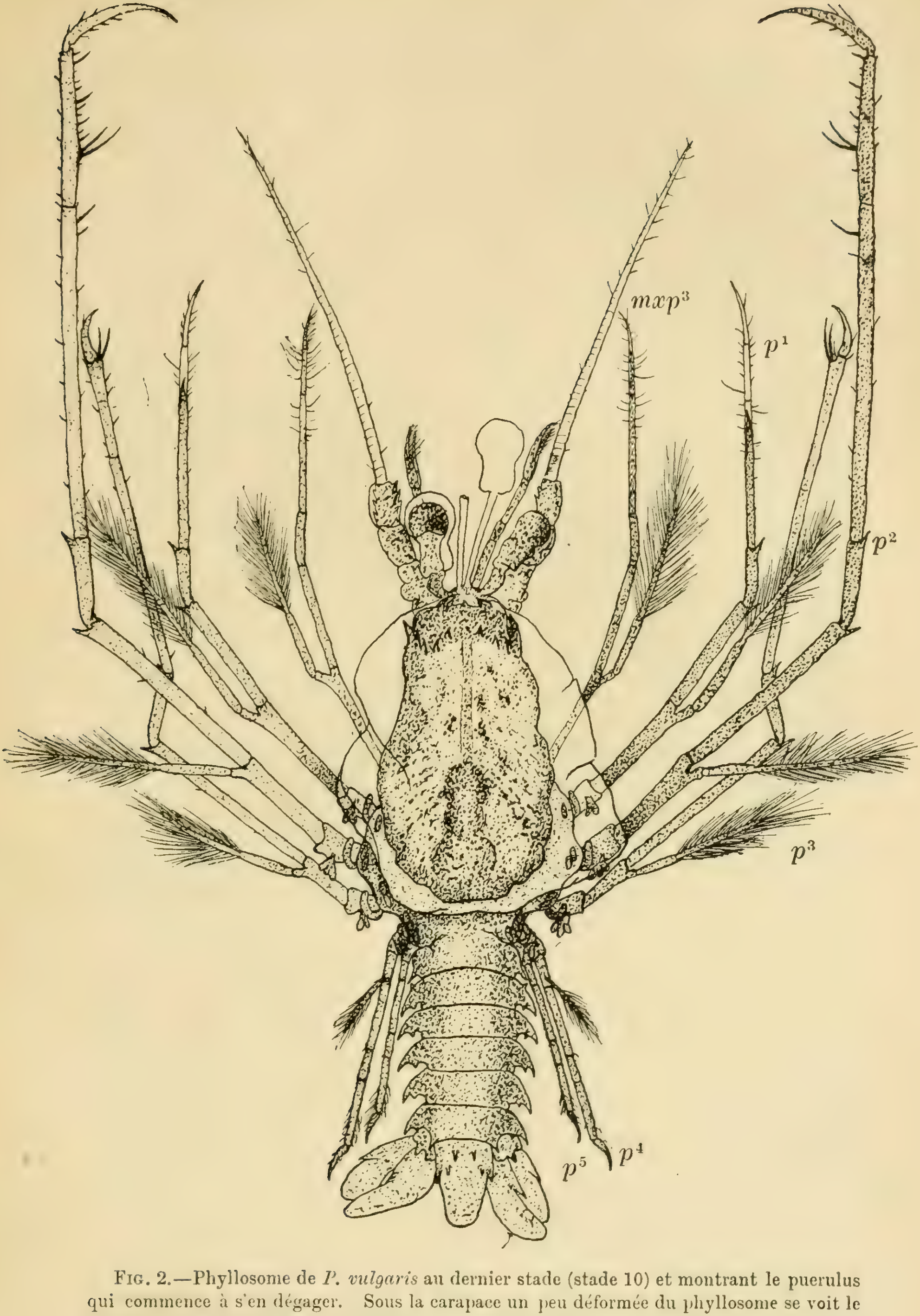

FIG. 2.—Phyllosome de *P. vulgaris* au dernier stade (stade 10) et montrant le puerulus qui commence à s'en dégager. Sous la carapace un peu déformée du phyllosome se voit le bouclier céphalo-thoracique du puerulus, un pédoncule oculaire de ce dernier est sorti du pédoncule phyllosomien, l'autre est encore coiffé de son exuvie ; certaines pattes commencent également à se dégager. Dessin de l'auteur d'après un exemplaire capturé dans les parages d'Eddystone. (Le cliché a été communiqué par "Science et Vie".) Gross. 4.

paires d'épines et les épimères abdominaux se terminent en pointe avec un denticule sur leur bord postérieur. Les longs fouets antennaires présentent des traces de segmentation et quelques soies ; les épipodites de *mxp. 1* et *mxp. 2* sont développés, la formule branchiale est celle de l'adulte et beaucoup de branchies présentent déjà quelques bourgeons. Je n'ai pu obtenir qu'un phyllosome à ce stade ; il fut capturé entre deux eaux le 25 août 1913, à 5 milles E.N.E. du phare d'Eddystone.

J'ai examiné les matériaux recueillis au cours de 46 pêches effectuées depuis le 20 juin 1913, jusqu'à la fin d'août. La plupart des pêches faites dans les parages d'Eddystone renfermaient des phyllosomes de *Palinurus vulgaris* et de *Scyllarus arctus ;* celles pratiquées en dehors de cette zône ne donnèrent aucun représentant de ces larves. Les pêches du mois de juin ne fournirent que de jeunes phyllosomes de *Palinurus*, mais je dois observer qu'au Laboratoire on avait conservé peu de matériaux de ces pêches ; à mesure qu'on avançait en juillet, les phyllosomes âgés devenaient nombreux et sûrement l'évolution peut s'achever durant ce mois, comme on le verra plus loin. D'ailleurs, durant toute la durée du mois d'août, la pêcha rapporta des phyllosomes âgés et des phyllosomes aux premiers stades ; on peut donc affirmer que *la Langouste commune*, dans les parages d'Eddystone, *effectue son développement post-embryonnaire au moins pendant toute la durée de l'été*, c'est-à-dire du 21 juin au 21 septembre.

II. Stade Natant ou Puerulus.

Caractères du puerulus. Pour des raisons que j'indiquerai plus loin, la capture de l'exemplaire précédent a une importance de premier ordre, au point de vue de la solution des problèmes qui nous occupent ; elle doit être mise sur le même rang qu'une seconde dont je vais tout de suite entretenir le lecteur.

Cette seconde capture est celle d'un puerulus qui fut pris le 31 juillet, entre deux eaux, dans les parages compris entre Looe et Eddystone, au-dessus d'un fond de 27–29 brasses. L'exemplaire fut trouvé par M. Gossen parmi les matériaux recueillis au cours de pêches que dirigeait M. Clark, Assistant du Laboratoire. Faut-il dire que j'éprouvai une joie profonde lorsqu'on apporta sur ma table de travail ce puerulus qui avait jusqu'alors échappé à la connaissance des zoologistes ?

L'unique et précieux exemplaire (figs. 3, 4, 5, 6) mesure environ 21 mm. de longueur, ce qui est la taille des grands phyllosomes. Comme tous les puerulus, il est hyalin, avec des téguments coriaces à peu près totalement dépourvus de calcification, et la forme macrourienne normale. Il se distingue pourtant des puerulus actuellement connus par son bouclier céphalo-thoracique regulièrement convexe, mais il est possible que cette disposition soit due au renflement des régions branchiales sous l'action de l'eau de mer où l'animal a péri, ou des liquides conservateurs ; dans les autres puerulus, en effet, la carapace est très peu convexe dorsalement, et ses régions branchiales forment un angle presque droit avec la région dorsale, disposition qui s'est conservée chez un certain nombre de Palinuridés primitifs (*Puerulus* Ortm. ; *Linuparus* Gray). D'ailleurs, notre puerulus est bien au " stade natant " décrit par M. Boas, car ses pléopodes peuvent se conjuguer par couples dans une même paire, grâce aux rétinacles à crochets qui occupent le bout distal de l'appendice interne situé sur leur rame endopodiale.

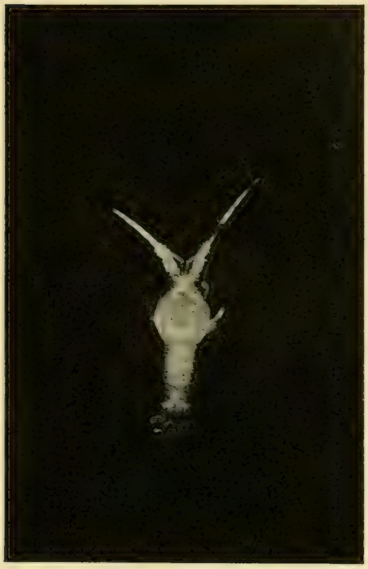

Fig. 3.

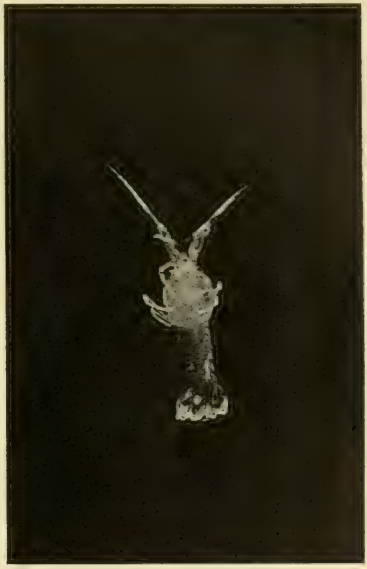

Fig. 4.

Fig. 3.—Puerulus de *P. vulgaris* capturé dans les parages d'Eddystone. Face dorsale (d'après une photographie de M. Martin Duncan prise au Laboratoire de Plymouth). Grandeur naturelle.

Fig. 4.—Puerulus de la Fig. 3, vu du côté ventral (d'après une photographie de M. Martin Duncan).

L'exemplaire capturé présente déjà de grandes resemblances avec la forme définitive du *Palinurus vulgaris ;* les antennules sont du même type brévicorne, c'est-à-dire terminées par deux courts fouets subégaux dont l'externe est beaucoup plus épaissi que l'autre ;—les antennes sont très fortes, avec un long et puissant fouet bien articulé et un large

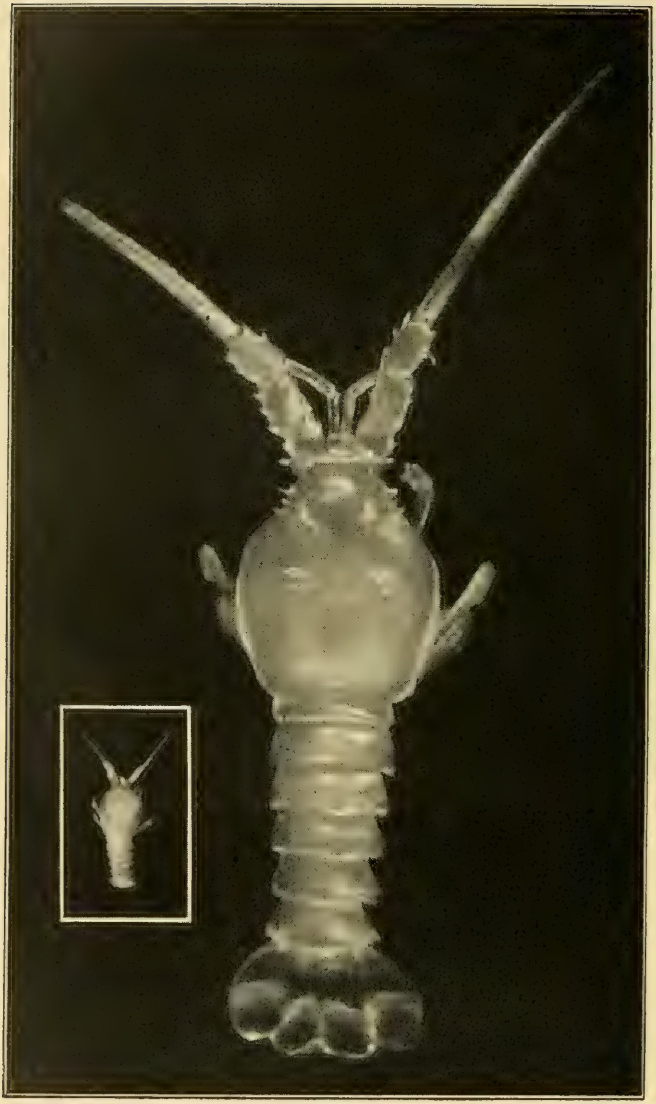

FIG. 5.—Puerulus des deux figures précédentes vu du côté dorsal. (Agrandissement photographique obtenu par M. Martin Duncan.)

pédoncule où les épines sont distribuées à très peu près comme chez la Langouste adulte ;—les pédoncules oculaires sont courts et larges ;—le rostre est réduit à une faible pointe médiane comme dans les espèces du genre *Palinurus* ;—les cornes rostrales sont très puissantes et suivies d'une paire d'épines post-rostrales ;—il y a sur la carapace quelques épines qu'on retrouve chez l'adulte (une rangée transverse de quatre épines gastriques, une paire de spinules cardiaques, et, au bord supérieur de chaque région branchiale, une dizaine de spinules disposées en série)—les épimères abdominaux sont aigus et, sauf le premier, munis d'une saillie en pointe sur leur bord postérieur ;—on observe une paire de fortes pointes sur le 6^{e} segment abdominal, à la naissance du telson ;—ce dernier présente déjà la paire d'épines proximales et les échancrures latérales épineuses de la Langouste adulte ;—les uropodes sont munis, comme dans cette dernière, d'échancrures externes spinuleuses, les pattes enfin sont courtes, fortes, et dépourvues d'exopodites* bien développés.

Il y a pourtant de profondes différences entre ce puerulus et la forme définitive de la Langouste commune ; outre les caractères généraux propres à tous les puerulus (corps hyalin, téguments coriaces et non calcifiés ; présence de rétinacles sur les appendices internes des pléopodes) il faut signaler surtout l'absence de denticulations aiguës sur les cornes rostrales (fig. 6), le développement de soies assez longues sur les fouets antennaires, l'absence de sillons transverses sur les segments abdominaux et surtout l'armature épineuse de la carapace qui est loin d'être riche et puissante comme dans la Langouste adulte. J'ai montré plus haut que les épines du puerulus se retrouvent à leur place dans la forme définitive ; cela est vrai pour toutes, sauf peut-être pour trois épines, probablement hépatiques, situées de chaque côté en arrière des antennes ; ces épines sont fortes et très caractéristiques de notre puerulus, mais il est difficile de leur trouver des homologues dans les nombreuses épines qui ornent le bouclier céphalo-thoracique de l'adulte.

Le puerulus d'Eddystone se rapproche surtout d'un puerulus caraïbe que j'ai rapporté (1912, 81) au *Palinurus longimanus* Edw. ; il présente comme lui un exopodite flagellé sur les maxillipèdes externes et plusieurs paires d'épines sternales ; ces dernières, toutefois, sont plus développées dans notre puerulus et d'ailleurs plus nombreuses, car on en trouve une à la base des pattes des quatre paires postérieures tandis que les épines se localisent à la base des trois dernières paires de pattes dans le puerulus caraïbe.

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* L'exemplaire avait perdu quelques-unes de ses pattes, mais celles qui restent sont courtes et fortes comme dans les puerulus des autres Palinuridés.

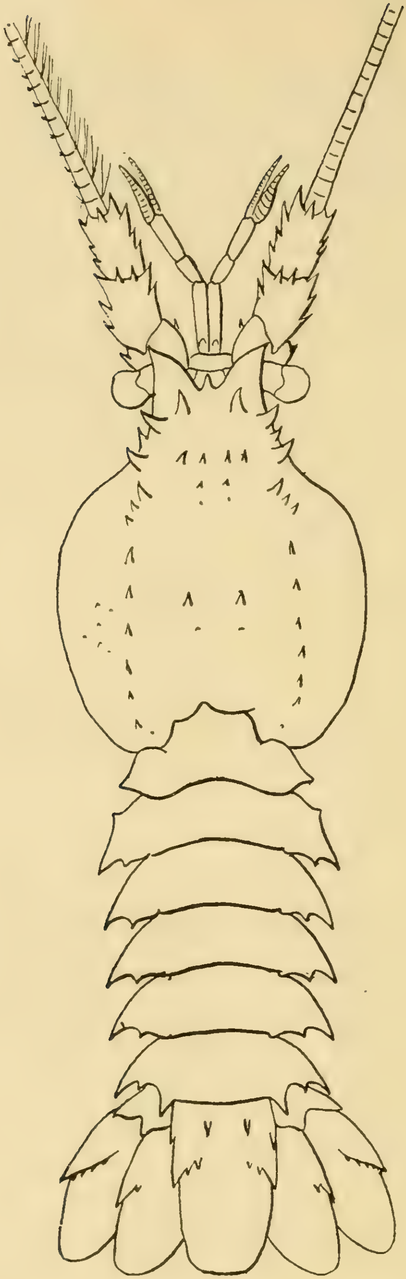

FIG. 6.—Esquisse du même puerulus montrant les ornements en saillie de la face dorsal. Dessin de l'auteur d'après l'exemplaire capturé dans les parages d'Eddystone. (Cliché communiqué par "Science et Vie".)

Passage du phyllosome au puerulus.—Si le puerulus ressemble beaucoup à la Langouste adulte, il ressemble par contre bien peu au phyllosome : avec ses pattes courtes de Crustacé marcheur, ses exopodites thoraciques réduites à un imperceptible bourgeon dépourvu de soies, ses pédoncules oculaires à tigelle très courte, surtout avec son bouclier céphalo-thoracique trapu et très différent du large et plat bouclier phyllosomien, le puerulus est aussi différent que possible de la forme larvaire des Palinuridés. Provient-il réellement de cette forme et comment s'effectue le passage de l'un à l'autre ? Voilà ce qu'il fallait encore trouver.

Par une bonne fortune singulière et qu'il eût été fou d'espérer, l'*Oithona*, sous la direction de M. Clark, fît capture d'un phyllosome dans lequel était en voie de se former et de se dégager le puerulus. Ce phyllosome est celui (fig. 2) dont j'ai donné plus haut la description et qui représente, à mon avis, le 10^{e} stade larvaire de notre Langouste, un stade que les zoologistes n'avaient pas encore observé. Son abdomen ressemble déjà tout à fait à celui du puerulus, mais le spécimen est bien phyllosome par tous ses autres caractères.

Ce phyllosome fut rapporté vivant par M. Clark qui me prévint de suite ; mais le délicate organisme avait succombé aux fatigues du voyage et était complétement inerte quand j'arrivai au laboratoire pour l'examiner. La nuit était venue, on le conserva dans l'alcool et j'en fis l'étude le jour suivant. Sa carapace était déformée et ses pédoncules oculaires avaient un aspect bizarre, si bien qu'il me parut être tout d'abord un phyllosome en mauvais état. Mais un examen plus attentif modifia bien vite cette conception trop rapide : l'abdomen avait des caractères tout particuliers propres au puerulus, et sous le bouclier céphalo-thoracique déformé, on apercevait, comme une masse opaque, le bouclier même du puerulus, avec son rostre minuscule, ses cornes frontales, ses fortes épines hépatiques et la plupart des spinules de la carapace (fig. 2). Le pédoncule oculaire droit du puerulus était déjà sorti du pédoncule phyllosomien ; le pédoncule oculaire gauche était également formé, indépendant de la tigelle phyllosomienne, pourtant coiffé encore du pédoncule phyllosomien ; certaines pattes du puerulus commençaient à se dégager des pattes phyllosomiennes.

En fait, c'était une pièce merveilleuse et singulièrement démonstrative que permettait d'établir sans contestation possible : 1° que *le phyllosome capturé représente bien le dernier stade larvaire de notre Langouste ;* 2° que *cette dernière ne traverse pas, comme d'autres Palinuridés, le curieux stade* PHYLLAMPHION *décrit et figuré par Reinhardt en 1858* ; 3° que *les con-*

ceptions de M. Boas sont parfaitement justes en ce sens que le puerulus est bien directement issu du phyllosome, du moins dans notre Langouste commune.

Par analogie, on devra étendre cette dernière et très importante conclusion à tous les Palinuridés, en remarquant toutefois que certaines formes exotiques traversent un stade *phyllamphion*, assez peu différent d'ailleurs du phyllosome.

Passage du puerulus à la Langouste.—Les observations précédentes nous donnent-elles le droit de conclure que le puerulus d'Eddystone est celui de la Langouste commune et, d'une manière plus générale, que les divers puerulus connus représentent le " stade natant " de divers Palinuridés ? Cela ne me paraît point douteux. Le *Palinurus vulgaris* représente à lui seul, dans nos mers, la famille des Palinuridés, d'où cette conclusion que tous les phyllosomes palinuriens capturés à Eddystone proviennent bien de cette Langouste. Nous en dirons autant du puerulus, car nous avons vu ce dernier prendre naissance au sein même des grands phyllosomes. Le puerulus d'Eddystone est donc, sans incertitude aucune, le " stade natant " du *Palinurus vulgaris*.

Il s'en faut que l'on puisse conclure, avec une précision semblable, lorsqu'on s'adresse aux autres formes de la famille, car on n'a jamais observé, dans ces dernières, la série complète des stades phyllosomes et moins encore le passage du phyllosome au puerulus. Mais j'ai largement établi, dans un travail antérieur (1912), que chaque puerulus présente des caractères qui permettent de le rapporter, presque sûrement, à une espèce spéciale de Palinuridés.

III. HABITUDES DES PHYLLOSOMES ET DES PUERULUS.

Toutefois les suppositions les plus logiques ne valent pas une bonne preuve et, en ce qui concerne la Langouste commune, il faudra observer le passage du puerulus à la forme définitive. Ce sera l'objet principal de mes recherches durant la campagne que je dois effectuer prochainement au laboratoire de Plymouth.

La principale difficulté sera d'obtenir des puerulus. On peut se les procurer par deux moyens : soit en élevant des phyllosomes de grande taille, soit en les capturant directement au large.

La première méthode sera sans doute la meilleure et la plus sûre, car l'élevage en aquarium des grands phyllosomes ne semble pas devoir être très difficile. M. Clark a capturé, dans les parages d'Eddystone, un phyllosome à l'avant-dernier stade et l'a rapporté vivant au laboratoire où j'ai pu l'observer pendant les deux jours qui précédèrent mon départ. Quoique placé dans une simple jarre et dans des conditions peu favorables, la curieuse larve paraissait très active et en fort bon état ; elle se déplaçait à peu près exclusivement au moyen de ses exopodites thoraciques, qui lui servaient aussi à se maintenir dans le milieu et à la diriger ; elle descendait lentement quand ces appendices n'étaient plus en fonction ; les pattes elles-mêmes font peu de mouvements et semblent jouer le rôle de balanciers, l'abdomen et ses pléopodes n'en font aucun. Le jeune animal est rapidement et fortement attiré par la lumière. A cet avant-dernier stade, les phyllosomes sont assez communs vers la fin de juillet et durant le mois d'août ; en les élevant dans un aquarium convenable, on pourra peut-être les conduire jusqu'au dernier stade et de celui-ci au " stade natant " ou puerulus.

La capture des puerulus en pleine mer sera plus difficile. Ces jeunes, en effet, ne doivent pas rester longtemps entre deux eaux, dans le milieu où ils se trouvent en sortant des phyllosomes, et où fut capturé l'exemplaire que j'ai décrit plus haut. *Ce sont des nageurs au corps lourd, qui doivent très vite descendre sur le fond* où ils se cachent certainement parmi les rochers*, car leurs téguments coriaces et non calcifiés les rendent très vulnérables. Ainsi doit s'expliquer, à mon avis, l'extrême rareté des puerulus dans les collections zoologiques et la diversité d'habitat jusqu'ici connue chez ces animaux : les puerulus étudiés par M. Boas avaient été, " en partie du moins, capturés au large " (1880, 84), et je sais, d'après les notes des pêches faites par la *Princesse Alice*, que le type du *puerulus atlanticus* (" stade natant " du *Palinurus regius* Br. Cap.) fut capturé au trémail par 20 mètres de profondeur, à Ste. Lucie du Cap Vert. D'un autre côté, M. Calman rapporte que le *puerulus spiniger*, Ortm. (" stade natant " du *Palinurus ornatus* Fab.) fut trouvé à l'île Christmas " soit au milieu des rochers, soit sur le " pier " dans les crevasses des piles " (1909, 444), et j'ai noté ailleurs (1912, 88) que le puerulus du *Panulirus dasypus* Latr. fut trouvé par M. le Dr. Jousseaume dans les crevasses du rivage, à Djiboutil.

Qu'ils soient obtenus par élevage ou par capture directe, les puerulus, à cause de leurs habitudes, se prêteront certainement beaucoup mieux que les phyllosomes à la captivité de l'aquarium. On pourra, sans difficulté, j'en suis sûr, les conduire jusqu'à la forme définitive de l'espèce à laquelle ils appartiennent. Cette forme sera sans doute acquise à la première mue, car les puerulus d'une espèce ont tous à peu près la même taille, et cette taille n'est pas moins grande que celle des plus jeunes Langoustes. En capturant à Djiboutil les puerulus du *Panulirus dasypus*, M. Jousseaume a recueilli plusieurs jeunes de l'espèce, et ces jeunes présentent la même taille et les mêmes variations de taille que les puerulus ; * le Muséum d'histoire naturelle possède un jeune exemplaire de la Langouste commune qui dépasse de 4 mm. seulement le puerulus d'Eddystone, et l'on trouverait sûrement des jeunes ayant la même taille que ce dernier. Quoiqu'il en soit, il n'est pas douteux que du puerulus sortira la Langouste sous sa forme définitive.

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* Il en est, sans doute, de même pour les Homards ; le bateau du laboratoire a capturé, entre deux eaux, un jeune Homard qui avait acquis tous les caractères definitifs de l'espèce ; le jeune venait sûrement de sortir de sa *mysis* qui est pélagique.

J'arrête là cette note préliminaire qui sera complétée et détaillée à la suite de mon prochain séjour au Laboratoire de Plymouth. Si, comme je l'espère, on lui trouve quelque intérêt, je dois en remercier toutes les personnes qui ont provoqué ou facilité mes recherches, c'est-à-dire les membres de la "Marine Biological Association," M. le Professeur Ray Lankester qui me désigna comme "investigator" au choix de cette Société, et, pour leur dévouement au-dessus de tout éloge, M. Allen, Directeur du Laboratoire de Plymouth, M. Clark, assistant, M. M. Gossen et Savage attachés au service, et sans aucune exception le personnel du Laboratoire. Je dois aussi remercier mon excellent confrère, M. F. Martin Duncan, qui travaillait au Laboratoire durant mon séjour à Plymouth et qui a très obligeamment photographié, peu après sa capture, le précieux puerulus recueilli par l'*Oithona*.

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* Les puerulus capturés par M. le Dr. Jousseaume mesurent de 15 à 19 mm. et les jeunes Langoustes 18 à 20.

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Observations nouvelles sur les *trachelifer,* larves lucifériformes de *Jaxea nocturna.*

Par

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Avec 11 Figures dans le texte.

Durant mon premier séjour au Laboratoire de Biologie maritime de Plymouth, en qualité de "first Ray Lankester Investigator," j'ai eu la bonne fortune de trouver un certain nombre d'exemplaires de la très curieuse forme larvaire découverte en Ecosse, près d'Arran, par G. Brook (1889) qui lui donna le nom de *trachelifer.* Ces exemplaires furent capturés au filet Petersen par l'*Oithona*, bateau du Laboratoire, entre Looe et Eddystone, le 13 août 1913. Ils appartiennent sans conteste à la forme même décrite par Brook et, comme eux, présentent les traits suivants qui sont fort caractéristiques (Fig. 1) ; un corps étroit, allongé tout à fait identique à celui des Crustacés décapodes du genre *Lucifer ;* —des yeux volumineux et courts entre lesquels fait saillir une petite pointe rostrale ;—des mandibules en forme de long crochet recourbé—une paire de crochets épiméraux sur le bord postérieur des segments 2 à 6 de l'abdomen ;—enfin un telson élargi en arrière et muni de soies sur son bord postérieur largement échancré. Brook n'a pas eu de peine à montrer que cette larve ne ressemble aux *Lucifer* que par sa forme et qu'elle s'en

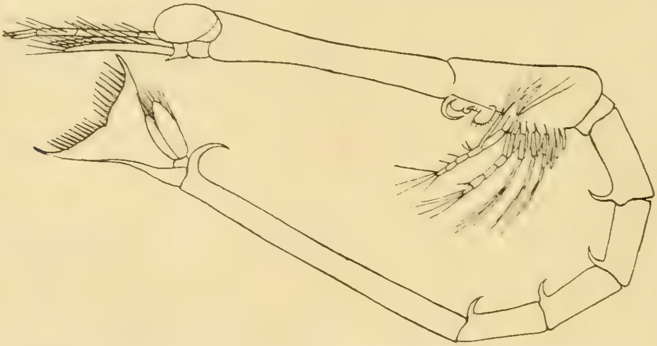

FIG. 1—Trachelifer au stade mysis imparfaite ; longueur 9 mm.

distingue par tous les traits essentiels ; mais il ne se crut pas en mesure d'émettre une opinion définitive sur ses affinités, d'autant que ses matériaux se limitaient à des individus relativement jeunes, les plus petits mesurant 6 mm. de longeur, les plus grands 9.

Au surplus, quelques années avant l'observation de Brook, la même larve avait été découverte dans l'Adriatique par Claus qui, sans lui donner un nom spécial, en fit d'abord (1884, 32) connaître deux stades jeunes, l'un de 4 mm. 5, l'autre de 7 mm. 5, puis (1885, 63–64) un stade beaucoup plus avancé (12 à 15 mm.), ce qui lui permit de regarder cette larve comme celle d'un rare Thalassinidé méditerranéen, la *Jaxea nocturna*, Nardo-Chiereghin (=*Calliaxis adriatica* Heller).

Depuis, dans un travail fort intéressant au point de vue bibliographique, M. T. Scott (1898, 268–269) rapporte qu'il a capturé le *trachelifer* dans le Golfe de Clyde et a étudié particulièrement un stade avancé dont le longueur atteint 16 mm. 5. La même larve a été retrouvée en abondance par ce zoologiste à Tobermory, détroit de Mull (1901, 481), et par son fils, M. A. Scott (T. Scott, 1901, 481) dans le Barrow Channel, près de Barrow-in-Furness, puis plus récemment (1905) dans les mers d'Irlande. Enfin cette larve, au stade le plus jeune, avait été recueillie en Méditerranée et décrite par M. G. Cano, qui en a donné une figuration (1891) ; d'après A. M. Norman et T. Scott elle aurait également été prise (1906, 13) par M. Robert Gurney au large de Salcombe, c'est-à-dire dans les eaux mêmes de la région de Plymouth.

Je dois ajouter, pour être complet, que M. T. Scott (1900, 405) a reçu des restes de la forme adulte trouvés dans l'estomac du Rouget ou "gurnard" (*Trigla gurnardus* L.) et du *Pleuronectes cynoglossus*, L., dans le Golfe de Clyde ; si bien qu'on doit croire, avec M. Scott, que la forme adulte habite réellement les eaux anglaises.

Là se bornent, à ma connaissance, les observations relatives à la curieuse larve ; comme elles sont fragmentaires et éparses, j'ai cru bon de les réunir en les augmentant de celles que j'ai pu faire au laboratoire de Plymouth sur les quelques exemplaires capturés par l'*Oithona*.

Stades larvaires actuellement connus.—A tous les stades actuellement connus, le *trachelifer* est franchement lucifériforme, ce qui le distingue nettement des *Lucifer* qui n'atteignent leur forme spéciale qu'à l'état de jeune immature, ainsi qu'il résulte des belles observations de M. W.-K. Brooks.*

Longueur 4 *mm.* (1er stade larvaire, zoé).—Ce stade a été décrit et particulièrement figuré par Claus (1884, 32, Figs. 48–50). Ses appendices buccaux sont développés, avec la mandibule gauche et le paragnathe en long crochet courbé, caractère tout à fait propre à cette larve et qui persiste à tous les stades ; la mandibule droite est normale ; les appendices thoraciques se réduisent aux deux paires de maxillipèdes antérieurs qui sont biramés et fonctionnels, du moins au point de vue de la natation. Le telson est élargi en arrière et très profondément échancré, beaucoup plus que dans les autres stades ; il ne porte qu'un petit nombre de soies.

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* W. K. Brooks. "*Lucifer*: a Study in Morphology" (*Philosoph. Transactions*, Vol. 173, p. 57–137, 11 Planches, 1883).

Longueur 6 *mm.* (zoé).—Stade étudié et figuré par Brook (1889, 420, Fig. 1). Les pédoncules antennulaires paraissent indivises et le fouet qui les termine est remarquablement court ; les antennes présentent une épine basilaire et deux branches subégales dont l'externe porte des soies et n'atteint pas l'extrémité distale des pédoncules antennulaires. Les mandibules conservent les traits du stade précédent ; les deux paires de mâchoires sont biramées. La troisième paire de maxillipèdes apparaît sous la forme d'un bourgeon simple, comme d'ailleurs les péréiopodes des deux premières paires. Les autres appendices ne sont pas encore développés et aucune ligne articulaire ne sépare le telson du dernier segment abdominal.

Longueur 7 *mm.* 5 (zoé).—Stade étudié par Claus (1884, 32). Les trois paires de maxillipèdes sont biramés et fonctionnels ; les péréiopodes sont tous représentés par des bourgeons.

Un stade un peu plus avancé a été décrit par Brook (1889, 420–421) : les péréiopodes antérieurs s'allongent en acquérant un exopodite fonctionnel ; les uropodes apparaissent à la base du telson qui est séparé du 6e segment abdominal. Les péréiopodes des deux paires postérieures ne seraient pas encore développés ce qui ne concorde guère avec les observations de Claus et semble pour le moins douteux. Ce stade est intermédiare entre la zoé et la mysis.

Longueur 9 *mm.* environ—(mysis imparfaite). C'est le dernier stade étudié par Brook et celui auquel appartiennent la plupart des exemplaires de l'*Oithona* ; les caractères schizopodiens sont indiqués par la division en exopodite et endopodite des six paires d'appendices thoraciques antérieurs, mais le stade mysis n'est pas encore complètement réalisé, car les exopodites des cinq paires antérieures fonctionnent seuls comme rames natatoires. Il convient de décrire ce stade dont Brook n'a fait qu'une étude incomplète (1889, 421, Fig. 2).

Les *antennules* (Figs. 1 et 2) sont longuement pédonculées mais les trois articles de leur pédoncule semblent peu distincts ; elles se terminent par deux courts fouets simples, l'un externe assez fort, l'autre interne plus long et plus grêle. Il y a de longues soies sur la face dorsale des pédoncules et à l'extrémité distale du fouet externe. Les *antennes* (Figs. 1 et 2) n'atteignent pas l'extrémité des pédoncules antennulaires ; leur second article présente une pointe antéro-externe et porte à son sommet deux longues branches subégales, simples l'une et l'autre : un exopodite ou écaille, longuement sétifère, un endopodite un peu plus long et dépourvu de soies.

Les appendices buccaux sont, comme dans le genre *Lucifer*, situés fort loin des yeux, juste derrière l'étranglement qui sépare du thorax la très longue et fort grêle région céphalique (Fig. 1), ils comprennent des mandibules, des maxilles, et des mâchoires (Fig. 3). Les paragnathes et *mandibules* (md) présentent toujours la forme curieuse signalée par Claus dans les exemplaires du premier stade, à savoir celle d'un crochet longuement recourbé. Je n'y ai pas vu de palpe. L'un des crochets m'a paru simple, l'autre était finement denticulé vers le bout distal. Les *maxilles* (mx^1) sont très normales avec un palpe simple muni au sommet de trois soies et une lacinie bien développée mais pauvrement sétifère ; je n'y ai pas vu de lame exopodiale. Les *mâchoires* (mx^2) ont également une structure normale ; leurs lacinies externe et interne sont armées de soies, mais indivises ; leur palpe est court, leur exopodite cilié. Je n'ai pu observer la partie postérieure de cette lame exopodiale.

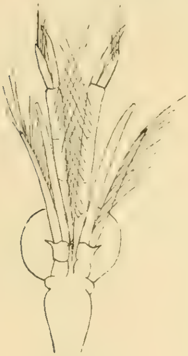

Fig. 2.

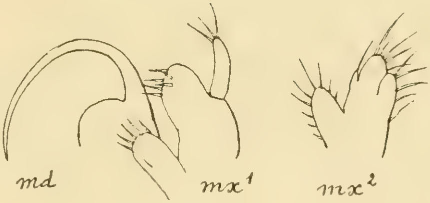

Fig. 3.

FIG. 2.—Trachelifer de la Fig. 1 : yeux, antennes et antennules vus du côté dorsal.

FIG. 3.—Trachelifer de la Fig. 1 : une mandibule (md), une maxille (mx^1), et une mâchoire (mx^2).

Les appendices thoraciques (Figs. 1, 4, et 5) sont au nombre de huit paires. Les *deux paires antérieures* (Fig. 4, maxillipèdes 1 et 2) se différencient de toutes les autres (Fig. 5) en ce sens que *l'article basilaire de leur exopodite est fusionné complètement avec l'article basal de l'endopodite,* d'où il résulte que la partie libre de l'exopodite se compose seulement de deux articles et la partie libre de l'endopodite de quatre ; le dernier article de l'exopodite se termine par six longues soies bipennées ; on

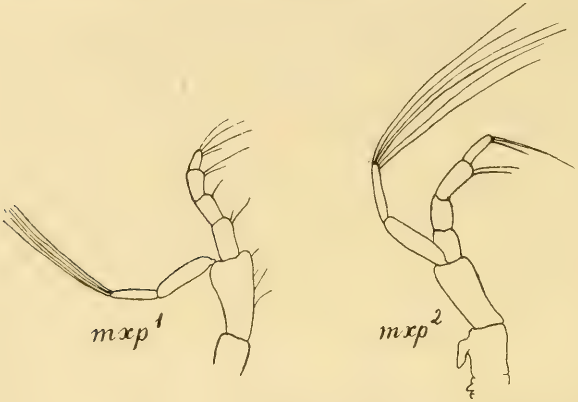

Fig. 4.—Trachelifer de la Fig. 1 : maxillipèdes de la 1re (mxp^1) et de la 2^{c} paires (mxp^2)

trouve également des soies sur les divers articles de l'endopodite (Fig. 4). Les appendices *des quatre paires suivantes* (Fig. 5, mxp.^{3}, p.^{1}, p.^{2}, p.^{3}) sont biramés comme ceux qui précèdent, *mais sans fusion basale de l'exopodite et de l'endopodite ;* si bien que, dans ces appendices, l'exopodite

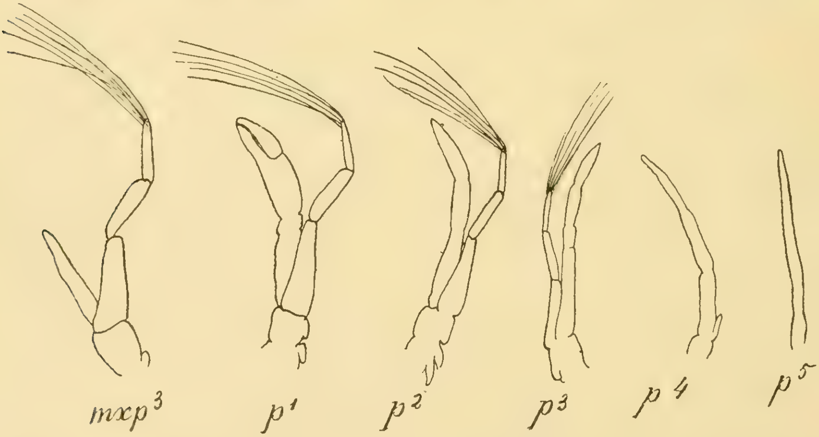

Fig. 5.—Trachelifer de la Fig. 1 : maxillipède postérieur et les cinq péréiopodes du même côté (p^1 à p^5).

se compose de trois articles libres. Au surplus, l'exopodite n'est sétifère et fonctionnel que dans les trois paires antérieures (maxillipèdes 3, péréiopodes 1 et 2), il se réduit à l'état de bourgeon dans ceux de la dernière paire (6^{e} paire thoracique representant les péréiopodes 3) comme d'ailleurs l'endopodite des quatre paires qui nous occupent. J'ajoute que ces bourgeons endopodiaux sont simples (Fig. 5), sans articulation apparente, toujours dépourvus de soies, très courts dans les appendices antérieurs, plus allongés en arrière où ils atteignent à peu près les dimensions de l'exopodite. Les appendices *des deux paires postérieures* (péréiopodes 4 et 5) *sont réduits à l'état de bourgeons simples*, privés de soies et non fonctionnels, ceux de la dernière paire étant un peu plus courts que les précédents (Fig. 5, $p.^4$, $p.^5$).

Ainsi le thorax des larves à ce stade porte six paires d'appendices biramés dont la sixième n'est pas fonctionelle et dont les deux premières se différencient de toutes les autres par la fusion basale de leurs exopodites et endopodites qui sont l'un et l'autre fonctionnels ; à partir de la troisième paire, les endopodites se présentent sous la forme de bourgeons non fonctionnels, comme les appendices des deux dernières paires qui, d'ailleurs, ne sont pas biramés.

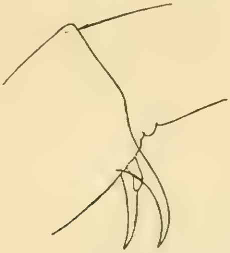

Fig. 6.

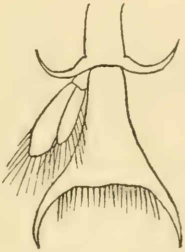

Fig. 7.

Fig. 6.—Trachelifer de la Fig. 1 : le 7^e segment abdominal avec ses épines postérieures et ses bourgeons pléopodiaux.

Fig. 7.—Trachelifer de la Fig. 1 : dernier segment abdominal, telson et uropode gauche.

Cette description des appendices thoraciques diffère beaucoup de celle qu'a donnée Brook ; car mon regretté prédécesseur n'a signalé ni la bifurcation des péréiopodes, ni la curieuse particularité des deux paires de maxillipèdes antérieures. Et ces deux caractères sont, à coup sûr, les plus importants dans la forme que nous étudions. J'ajoute que Brook mentionne simplement, sans les décrire, les maxilles et les mâchoires.

L'abdomen (Figs. 1, 6, 7) présente les caractères signalés par Brook, avec de longues pointes épimérales (nulles sur le premier segment, particulièrement longues sur le sixième) et un telson très élargi en arrière où il présente 11 ou 12 paires de soies spiniformes (Fig. 7). La caractéristique du stade dont nous faisons l'étude, c'est l'apparition des uropodes (Fig. 7) qui se composent de deux lames sétifères subégales beaucoup plus courtes que le telson. Les pléopodes font défaut ou, dans quelques cas très rares, apparaissent sous la forme d'un très court bourgeon (Fig. 6).

Longueur 10 *à* 11 *mm.* (mysis).—Un exemplaire capturé par l'*Oithona* diffère des précédents en ce sens que les exopodites des appendices thoraciques de la 6e paire (péréiopodes 3) sont fonctionnels et que l'endopodite des péréiopodes de la paire antérieure commence à se fendre pour produire la pince (Fig. 8). C'est le stade mysis proprement dit.

Longueur 13 *mm.* (stade mysis à chélipèdes).—Ce stade n'a pas été signalé jusqu'ici ; il est représenté dans les récoltes de l'*Oithona* par un seul individu. Cet exemplaire ressemble tout à fait à ceux qui précédent par la structure du corps, mais il s'en distingue par les caractères suivants, dont certains ont une grande importance.

Les pédoncules antennulaires sont fort nettement triarticulés ; les antennes présentent une épine antéro-inférieure sur chacun de leurs deux articles basilaires, leur endopodite se différencie en une hampe basale et un fouet ; ce dernier dépasse notablement les antennules mais n'est pas encore brisé en articles.

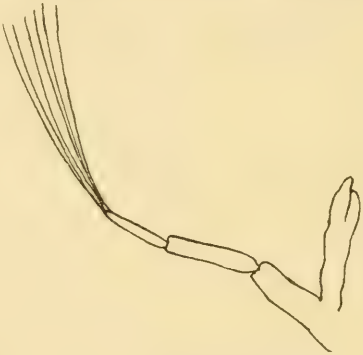

FIG. 8.—Trachelifer au stade mysis, long de 10 mm.: un péréiopode antérieur avec l'endopodite commençant à se transformer en pince.

Les pléopodes abdominaux se développent sur les segments 2 à 5 sous la forme de bourgeons allongés et bifurqués (Fig. 8). Les rames des uropodes restent subégales, et dépassent notablement le milieu du telson. L'échancrure terminale de celui-ci est limitée en avant par un bord presque rectiligne et sur les côtés par les deux pointes normales, qui sont divergentes et presque droites.

Les appendices buccaux et les yeux ne présentent rien de particulier ; les appendices thoraciques sont en même nombre qu'au stade précédent, de même type, et doués des mêmes fonctions, les appendices de la 6e paire (péréiopodes 3) étant semblables aux précédents en ce sens que leur exopodite est sétifère et fonctionnel (Fig. 9 et p.^{3}, Fig. 11). Il faut signaler à ce stade le développement d'un très court bourgeon exopodial

(Fig. 9 et p.^{4}, Fig. 11) à la base des appendices de la paire suivante (péréiopodes 4) ; la présence de cet exopodite rudimentaire montre qu'il faut considérer comme un endopodite les appendices assez réduits et très vaguement articulés qui représentent les deux dernières paires de péréiopodes (Fig. 8 et p.^{4}, p.^{5}, Fig. 11).

Mais ce qui distingue surtout notre exemplaire et lui donne une signification importante, c'est la structure des appendices de la 4^e paire (Fig. 9 et p.^{1}, Fig. 11) qui répresentent, comme on sait la paire antérieure des péréiopodes des Crustacés décapodes ; *dans cette paire, l'endopodite se termine par une pince bien formée* et présente des lignes articulaires assez nettes ; d'ailleurs les deux pinces sont égales et semblables, très développées et à peu près aussi longues que le reste de l'endopodite ; leurs doigts ont à peu près la même longueur que le reste de la portion palmaire et laissent entre eux un léger hiatus.

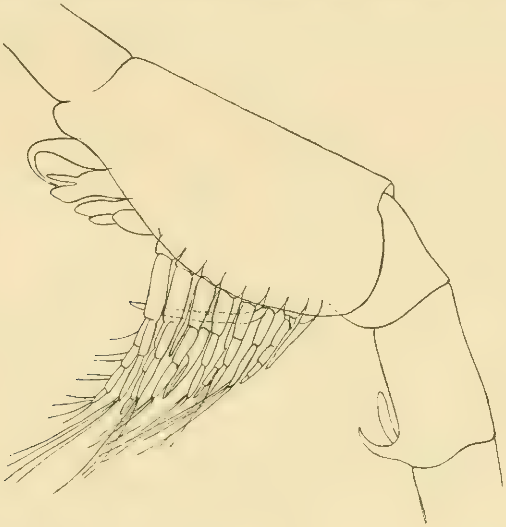

Fig. 9.—Trachelifer au stade mysis à chélipèdes (long. 13 mm.) : thorax avec un appendice et partie antérieure de l'abdomen.

J'ajoute qu'on observe des bourgeons branchiaux sur tous les appendices thoraciques, depuis la deuxième paire jusqu'à la septième (Figs. 10 et 11).

Longueur 15 *à* 16 *mm.* (dernier stade mysis). Je n'ai pas eu d'exemplaires à ce stade qui a été étudié par Claus (1885, 63–64, Taf. V., Fig. 45) avec le plus grand soin, du moins en ce qui regarde la région thoracique. C'est un stade mysis, comme les deux précédents.

Ce stade diffère de celui que je viens de décrire par la segmentation très nette des appendices thoraciques, par la réduction plus grande des deux paires postérieures de péréiopodes, et par l'allongement de l'exopodite des péréiopodes 4 qui restent non fonctionnels, enfin et surtout par ses branchies qui sont en même nombre que dans les *Jaxea* et déjà divisées en lamelles branchiales.

Je crois bien qu'il faut rapporter à ce stade l'exemplaire de 16 mm. brièvement décrit et figuré par M. T. Scott (1898, 269, Pl. 12, Figs. 16–20). A vrai dire, M. Scott ne mentionne pas les branchies mais l'examen qu'il fit de son exemplaire fut certainement très rapide, si j'en juge d'après les Figures 19 et 16 du travail, qui sont défectueuses.

Conclusions.—M. Scott rappelle, dans son intéressante note, tous les travaux relatifs à la curieuse larve que nous venons d'étudier. Son travail, à ce point de vue, offre au vif intérêt, et je dois remercier mon excellent collègue M. Calman qui, par l'intermédiaire de M. Allen, a eu l'obligeance de me le faire connaître. Sans cet avis précieux, je me serais borné peut-être à faire une comparaison entre les stades que j'ai décrits et ceux observés par Brook, alors que cet auteur n'a pas reconnu les affinités de sa larve *trachelifer* et qu'il ignorait, non seulement le travail où Claus a pour la première fois signalé cette larve (1884), mais en outre celui où l'éminent zoologiste de Vienne donna une exacte signification de sa découverte (1885). Or, cette dernière étude est de grande importance : Claus a observé, en effet, que la bizarre larve capturée à Trieste présente, en dépit de sa forme, tous les caractères essentiels des larves des Thalassinidés, qu'elle ressemble tout à fait, par ses caractères, aux

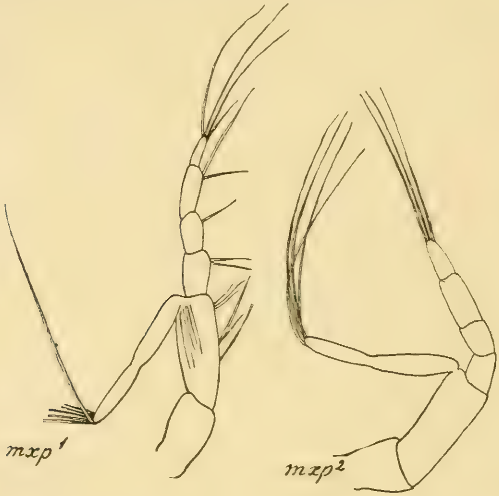

FIG. 10.—Trachelifer de la Fig. 9 : les maxillipèdes des deux premières paires.

larves de *Gebia littoralis* Risso supérieurement étudiées par M. G. O. Sars,* qu'elle possède le même nombre de branchies que le *Calliaxis adriatica* et qu'il faut la considérer comme la forme larvaire de ce Thalassinien.

Cette identification ne saurait faire le moindre doute ;† elle peut même être poussée jusqu'au détail, car dans les figures données par M. G. O. Sars, on voit que les exopodites des maxillipèdes des deux paires antérieures se distinguent des autres par la fusion de leur article basal avec le deuxième article de l'endopodite. Nous avons montré plus haut qu'il en est de même dans le *trachelifer*. J'ajoute, comme Claus l'a d'ailleurs observé, que les *trachelifer* au stade mysis avancé sont dépourvus de pléopodes sur le segment abdominal antérieur et que leurs péréiopodes des deux dernières paires restent à l'état de bourgeons non fonctionnels, deux caractères également propres aux mysis de *Gebia*.

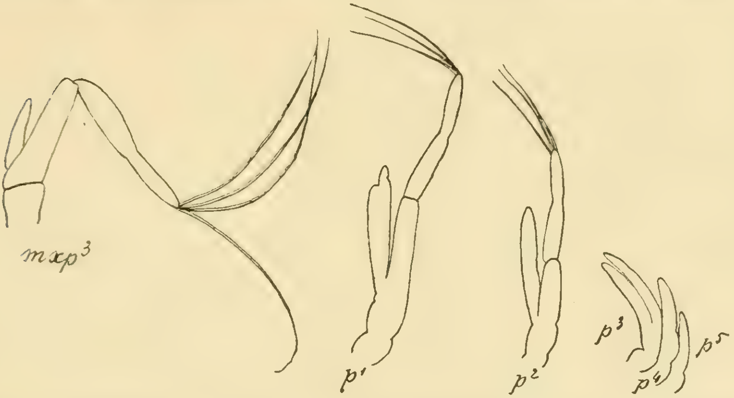

FIG. 11.—Trachelifer de la Fig. 9 : maxillipède postérieur et les cinq péréiopodes du même côté.

M. G. O. Sars signale cinq stades larvaires dans le développement de la *Gebia littoralis ;* 1°, au premier stade, qui est celui de zoé, les deux paires antérieures de maxillipèdes sont fonctionnelles, et l'on observe les bourgeons, parfois bifurqués, de presque tous les appendices thoraciques suivants, sauf ceux de la dernière paire ; 2°, la deuxième forme larvaire tient le milieu entre la zoé et la mysis ; tous les appendices thoraciques sont développés et tous, sauf ceux des deux dernières paires, ont une branche endopodiale et une branche exopodiale, mais cette dernière n'est fonctionnelle que dans les quatre paires antérieures (les

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* G. O. Sars. "Bidrag til Kundskab on Decapodernes Forvandlinger. I. Nephrops, Calocaris, Gebia" (*Arch. for Math. og Naturvid.*, B. IX, pp. 155–204, Pls. 1–7, 1884).

† Elle est d'ailleurs acceptée par M. M. Korschelt et Heider qui ont identifié (1892, 471) le *trachelifer* avec la larve de Claus, par M. Scott (1899, 69) et par M. Calman (1909, 301).

trois paires de maxillipèdes et les péréiopodes 1) ; 3°, la troisième forme larvaire correspond au stade mysis, mais c'est une mysis dépourvue d'exopodites sur les péréiopodes des deux dernières paires, les exopodites des autres appendices thoraciques étant d'ailleurs fonctionnels ; il y a des bourgeons de pléopodes, le telson est séparé du 6e segment abdominal qui porte en arrière des uropodes biramés ; 4°, au dernier stade larvaire, la structure est à peu près identique, mais les pinces commencent à présenter une échancrure digitale et les pléopodes sont allongés avec une seule branche. Au stade suivant, la forme *Gebia* est réalisée.

Tels sont les quatre stades larvaires indiqués par M. G. O. Sars ; on doit les considérer comme des stades essentiels reliés entre eux par des intermédiaires qui se manifestent à la suite de mues. Du moins en est il ainsi dans notre *trachelifer* :—les trois premières formes décrites plus haut (4 à 7 mm.) dans cette larve sont des zoés à divers stades, les plus simples sans appendices thoraciques autres que les maxillipèdes des deux paires antérieures, les plus avancés ayant les caractères des larves de *Gebia* au 2e stade, mais en plus les péréiopodes postérieurs et des uropodes biramés :—la forme suivante (9 mm.) est une *mysis* imparfaite qui n'est pas encore au stade 3 de la *Gebia*, car les exopodites des péréiopodes y sont à l'état de bourgeons non fonctionnels ; il est probable qu'une simple mue suffit pour que ces bourgeons deviennent natatoires, et que la mysis parfaite des Thalassiniens soit réalisée ;—à la mysis typique font suite, dans le *trachelifer*, trois stades mysidiens successifs (10 à 16 mm.) où les péréiopodes antérieurs se terminent par des pinces de plus en plus parfaites, où les branchies sont de plus en plus développées, et où les pléopodes acquièrent progressivement leurs deux rames, le premier de ces stades mysidiens à pinces correspond à très peu près au 4e stade larvaire décrit par Sars dans la *Gebia littoralis*.

Ainsi, Claus avait amplement raison de regarder la forme larvaire qui nous occupe comme une larve de Thalassinidé, et sans doute aussi avait-il raison de voir dans cette forme curieuse la larve de la *Jaxea nocturna ;* elle ne saurait être rapportée, en effet, aux autres Thalassinidés méditerranéens qui tous ont une forme larvaire plus différente de celle des *Gebia ;* et d'autre part, Claus observe qu'à un stade avancé elle présente les mêmes branchies que la *Jaxea nocturna*.

Faut-il croire, avec Claus, qu'une mue devra suffire pour conduire de cette larve lucifériforme avancée à l'individu présentant les caractères de l'adulte ? J'ai sous les yeux deux exemplaires de *Calliaxis adriatica* envoyés jadis au Muséum par Heller ; ils sont tout à fait d'un type astacien et si différents du *trachelifer* qu'on pourrait mettre en doute la possibilité d'un passage direct de l'un à l'autre. Dans les Thalassinidés comme chez les Paguriens et les Macroures marcheurs cuirassés (Palinuridés, Scyllaridés), un stade intermédiaire doit rattacher la forme adulte à la forme mysidienne, un *stade natant* (pour me servir d'une terme fort juste emprunté à M. Boas) où la forme se rapproche déjà beaucoup de celle de l'adulte, et où la natation s'effectue au moyen des pléopodes dont l'appendice interne présente des rétinacles. Le jeune de *Gebia littoralis* figuré par M. G. O. Sars (1884, Taf. V, Fig. 1) est certainement à ce stade intermédiaire, il mesure environ 6 mm.

Le stade natant de la *Jaxea nocturna* peut-être imaginé un peu plus long et plus grêle, parce que l'adulte diffère de la *Gebia littoralis* au point de vue de la gracilité du corps ; par une contraction et une condensation analogues à celles qui se produisent dans le phyllosome passant au puerulus, le trachelifer lucifériforme long de 15 à 16 mm. donnera un natant plus court de moitié et présentant déjà la forme des Jaxées adultes. Cette forme, d'ailleurs, sera aisément reconnaissable à ses pinces astaciennes, qui sont déjà fort longues dans les mysis et qui le sont plus encore chez l'adulte. Ainsi le petit organisme sera aisé à reconnaître et on le trouvera sans doute quelque jour dans les pêches pélagiques au filet fin.

C'est une capture que l'on peut faire à Plymouth, dans les parages de Looe—Eddystone où l'*Oithona* fit l'heureuse trouvaille des exemplaires étudiés dans le présent opuscule. Là également devra-t-on rechercher la forme adulte, *Jaxea nocturna*, mais alors au moyen de pêches effectués sur le fond, au chalut plutôt qu'à la drague. Cette dernière recherche sera certainement bien plus difficile que la première, car la Jaxée adulte est un animal rarissime, trouvé seulement à Trieste, puis à Naples où d'après S. Lo Bianco (1898–99, 503) on n'en put prendre qu'un exemplaire au cours de 25 ans.*

Voilà pour les travailleurs du Laboratoire de Plymouth, un sujet de recherches tout indiqué. Grâce au concours de tout le personnel du Laboratoire, surtout au zèle obligeant de M. le Directeur Allen et de M. Clark, on sait aujourd'hui que la *Jaxea nocturna*, déjà connue à Salcombe sous la forme de larve, habite aussi le voisinage immédiat de Plymouth. Il n'y a pas lieu de douter qu'on trouvera quelque jour, dans les mêmes eaux, le stade natant inconnu et l'adulte de cette espèce.

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* Cet exemplaire fut capturé non loin de la station zoologique, par 15 mètres de profondeur, sur fond de vase et sable fin.

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1902. Id. Notes on Gatherings of Crustacea collected by the Fishery steamer *Garland* and the Steam trawlers *Star of Peace* and *Star of Hope*, of Aberdeen, during the year 1901. (*Twentieth Annual Report Fishery Board of Scotland*, for the year 1901, p. 481, 1902.)

Quelques mots sur la variabilité du *Pycnogonum littorale,* Ström.

Par

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Avec 2 figures dans le texte.

DURANT mon séjour au Laboratoire de Biologie maritime de Plymouth, j'ai eu l'occasion d'examiner un lot très important de *Pycnogonum littorale*, Ström, qui se trouvait dans les collections de l'établissement depuis le 8 juillet 1908. Ce lot ne comprenait pas moins de 3268 individus. Il avait été recueilli au Barbican Pool, vieux port de Plymouth, dans les filets de pêcheurs qui avaient fait leur capture, disaient-ils, à 200 milles O. N. O. des Iles Scilly. Les exemplaires étaient beaucoup plus nombreux, mais le Laboratoire n'avait pas cru devoir en conserver davantage.

Je ne crois pas qu'on ait signalé jusqu'ici une pareille abondance des Pycnogonides de cette sorte ; évidemment l'espèce devait pulluler aux lieux où elle fut prise. C'est le premier point sur lequel il me semble utile d'attirer l'attention.

J'ai voulu profiter de cette pêche miraculeuse pour mettre en lumière quelques autres faits relatifs à l'histoire du dit *Pycnogonum.*

J'ai constaté tout d'abord que l'espèce atteignait, au point où elle fut prise, des dimensions plutôt fortes ; les femelles mesuraient en moyenne 13 mm. du bout de la trompe à l'extrémité postérieure de l'abdomen ; les mâles 11 mm. au plus. Les mâles sont à peu près de moitié moins nombreux que les femelles : ces dernières étaient représentées dans la collection par 2082 individus ; les mâles par 1186. Sur ce nombre 185 seulement étaient porteurs de masses ovigères.

Ces observations peuvent avoir un léger intérêt mais ce n'est point pour les faire que j'ai passé en revue, successivement, tous les exemplaires capturés ; je voulais profiter de la récolte pour étudier les variations du *Pycnogonum littorale* en un même lieu, surtout espérant trouver, dans cette abondante récolte, un individu anormal quant au nombre des pattes. Mon espoir a été complètement déçu : l'espèce est remarquable par la fixité de ses caractères, les seules variations qu'on y observe sont très légères et relatives à l'inflexion plus ou moins grands de la trompe, au pigment des yeux, au développement des tubercules dorsaux.

Tous les exemplaires avaient le nombre normal d'appendices ; tous, sauf un seul (Fig. 1), sur lequel je crois utile d'attirer l'attention. Cet exemplaire est une grande femelle très asymétrique présentant quatre pattes du côté droit et trois du côté gauche : la dernière patte droite (Fig. 2, p.^{4}) est dirigée en arrière suivant l'axe du corps avec un très gros tubercule dorsal sur son article basilaire ; l'abdomen (ab.), faiblement dilaté en arrière, est rejeté obliquement du côté gauche entre la patte précédente (p.^{4}) et la dernière, ou troisième (p.^{3}) du côté gauche. Cette anomalie bizarre me paraît due à l'ablation accidentelle de la quatrième patte gauche, non pas chez l'adulte, mais chez l'individu très jeune, alors que les pattes de la quatrième paire étaient encore à l'état de frêles bourgeons ; car on ne voit plus traces, dans l'exemplaire, de la patte perdue.* Ainsi

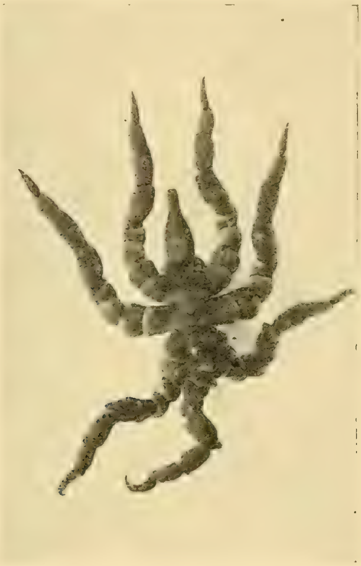

FIG. 1.—Femelle anormale de *Pycnogonum littorale* ; vue du côté dorsal et grossie 2 fois.

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* La disparition de la 4^e patte gauche a eu pour résultat de faire disparaître l'orifice sexuel correspondant ; notre exemplaire ne possède qu'un orifice sexuel, celui du côté droit (*og*).

un espace serait devenu libre en arrière du côté gauche, et aurait été occupé par l'abdomen et la dernière patte droite.

Il résulte des observations précédentes que le nombre des pattes est absolument constant dans notre *Pycnogonum*. Comme ces appendices se développent successivement d'avant en arrière, il semblerait possible qu'anormalement une cinquième paire pût prendre naissance et, plus possible encore, que la quatrième paire ne se produisît pas. Ces deux anomalies pourraient être interprétées comme le premier pas vers des formes nouvelles qui, dans le premier cas, seraient décapodes, et dans le second, simplement hexapodes. Mais elles ne semblent pas pouvoir se produire et, comme on connaît d'ailleurs trois genres de *Pycnogonides* à dix pattes (*Decolopoda*, *Pentanymphon*, *Pentapycnon*) appartenant aux familles les plus diverses, il semble naturel de considérer la forme décapode comme une forme ancestrale qui, par réduction dans le nombre des pattes, a conduit au type actuel du groupe, je veux dire au type décapode.

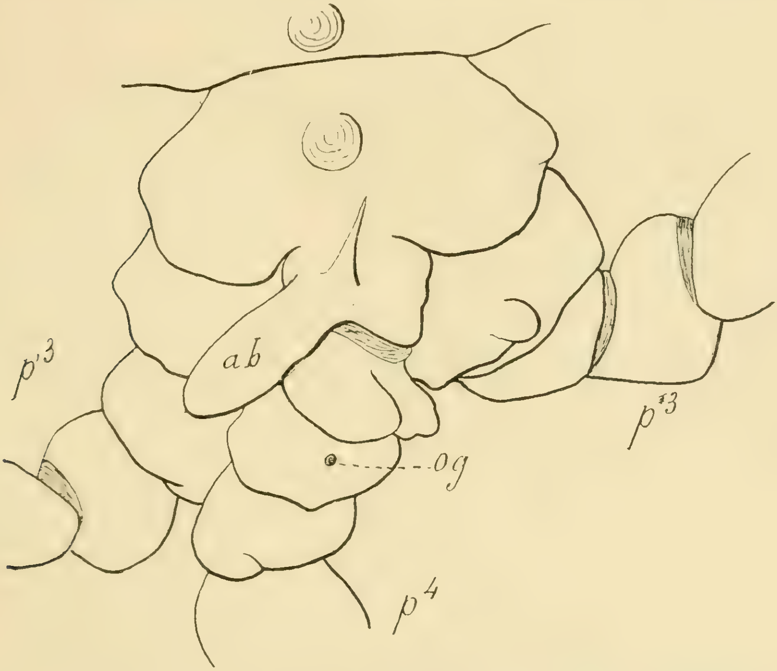

FIG. 2.—Extrémité postérieure très grossie de la même femelle ; côté dorsal.

Appendices.—Je viens de recevoir du Laboratoire de Plymouth une petite collection de *Pycnogonum littorale* recueillie par le S.S. *Albatross*, au large de Bishops (à 200 milles O. par N.), le 8 décembre 1913. Cette collection comprend 44 exemplaires dont 21 ♂ et 23 ♀. Le corps des plus grands mâles (céphalothorax + abdomen) mesure 8 mm., celui des plus petits 7 ; la taille des femelles varie entre 10 mm. et 8 mm. ; dans les femelles de 8 millimètres, l'orifice sexuel apparaît fort distinctement, mais ne semble pas encore fonctionnel. Ainsi, les femelles où le sexe commence à se manifester quelque peu extérieurement égalent au moins la taille des plus grands mâles. Les mâles, pour une moitié, sont chargés de pontes relativement récentes et tous semblent avoir atteint la maturité sexuelle.

On Some Plymouth Holothurians.

By

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Naturalist at the Plymouth Laboratory.

With 13 Figures in the Text.

TABLE OF CONTENTS.

PART I.

PAGE
On the specific characters of *Cucumaria normani* Pace, and *Cucumaria saxicola* Brady and Robertson, with an account of some undescribed differential characters and an investigation of the variation of the gonad in *C. saxicola*
Comparison of the characters of *C. normani* and *C. saxicola* 211
Variation of the gonad of *C. saxicola* 214
The gonad of *C. normani* 217
Characters of the calcareous collar of *C. saxicola* and of *C. normani* 219
Characters of the spicules and tube-feet in *C. saxicola* and *C. normani* 220
Discussion of some former observations on *C. saxicola* and *C. normani* . . . 222
The growth-stages of the bell-shaped spicules of *C. normani* 224
The synonymy of *C. saxicola* Brady and Robertson and of *C. normani* Pace . 225
Correlation in the characters of the gonad and ambulacra in the genus *Cucumaria* 228

PART II.

On the occurrence of *Cucumaria elongata* Düb. and Kör. and *Thyone raphanus* Düb. and Kör. in the Plymouth District 229
Notes on *Cucumaria elongata* 230
On *Thyone raphanus* Düb. and Kör. 232

PART I.

ON THE SPECIFIC CHARACTERS OF *CUCUMARIA NORMANI* PACE, AND *CUCUMARIA SAXICOLA* BRADY AND ROBERTSON, WITH AN ACCOUNT OF SOME UNDESCRIBED DIFFERENTIAL CHARACTERS AND AN INVESTIGATION OF THE VARIATION OF THE GONAD IN *C. SAXICOLA*.

COMPARISON OF THE CHARACTERS OF *C. NORMANI* AND *C. SAXICOLA*.

Some of the specific and differential characters of these two species have already been enumerated by Pace (1). Subsequently Norman (2) denied that these two forms were different, so that the literature on them was left in an unsatisfactory state. On investigating these two forms, however, I have obtained sufficient evidence—from the characters of the gonadial tubes, the calcareous collars, and the young of both forms—to verify the observations of Pace and to meet satisfactorily the objections put forward by Norman against them. The differential characters of these two species as given by Pace (loc. cit.) have been verified in an unpublished investigation by Mr. W. De Morgan and by the present writer. These characters, most of which were observed by Pace, are now given revised * in the following table in a comparative manner, so that the differences between these two species can be readily shown :—

TABLE 1.—A comparison and a contrast of the characters of *C. saxicola* Brady and Robertson and *C. normani* Pace.

Cucumaria saxicola B. and R.	*Cucumaria normani* Pace.
† Common on the shore, also taken in depths of a few fathoms.	† Fairly common on the shore, also taken in depths of a few fathoms.
General colour of body a pure milk white, becoming black when exposed to light.	General colour of body dirty brownish white, becoming black when exposed to light.
Surface of body smooth.	Surface of body much wrinkled.
Body wall delicate, relatively thin, marked only with transverse striæ due to encircling fibres of the superficial muscle layer, with relatively few spicules.	Body wall tough, coriaceous, crowded with spicules.
General body spicules devoid of nodulation, lozenge-shaped in one stage of growth, but subsequently developing 2 or even 3 additional foramina on the ends of the spicule and thus losing their lozenge shape. (See 4, Plate LXXII, Fig. 3.)	General body spicules typically lozenge-shaped, perforated with four large foramina, and always bearing on each side about 12 very prominent nodules. (See 3, Plate XI, Fig. 1.)

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* Owing to the fact that both species develop black pigment when and where exposed to light, it follows that the differential characters depending upon the degree of pigmentation of the tentacles and anal aperture noted by Pace cannot be relied upon, and have consequently been abandoned.

† As an example for illustrating the occurrence of these two forms, in one day's collecting on the shore (3rd April, 1911, Wembury Bay) about 80 *C. saxicola* were obtained and only about 6 *C. normani*, including specimens of various sizes. Another day (1st May, 1911) about 40 *C. saxicola* were obtained and only 2 *C. normani*. This disproportion is usual in this district.

Cucumaria saxicola B. and R.	*Cucumaria normani* Pace.
Surface spicules of body irregular in shape, consisting of rods radiating from a central portion, scattered in the skin. (See l.c. above and also Fig. 6, p. 221.)	Surface spicules campanulate, forming a continuous covering in the skin of the body. (See Figs. 8 and 7, pp. 225 and 222.)
Podial spicules have foramina typically in a single series. (See Fig. 6, p. 221.)	Podial spicules have foramina in two or more parallel rows or with a group of 3 or 4 small foramina at each end of the spicule. (See Fig. 7, p. 222.)
Gonadial tubes relatively few, varying in number between 10 and about 60, large, and club-shaped. (See Fig. 1, p. 214.)	Gonadial tubes very numerous, frequently more than 500, relatively small, and of even cylindrical calibre. (See Fig. 2, p. 214.)
Calcareous collar relatively delicate. Interradial calcareous pieces deeply bifurcated posteriorly. (See Fig. 4, p. 218.)	Calcareous collar relatively strong. Interradial calcareous pieces only slightly bifurcated posteriorly. (See Fig. 5, p. 219.)
Dorsal ambulacra with modified tube-feet. (See Fig. 9, p. 228.)	Dorsal ambulacra with ordinary ambulatory tube-feet.
Spawning period about May.	Spawning period about March.

The differential characters of most importance in the foregoing table are (1) those of the main body spicules, (2) the spicules near the surface of the body, (3) the shape and number of the gonadial tubes, and (4) the shape and relative stoutness of the pieces of the calcareous collar. Pace has already emphasized the first and second of these characters. These have, however, gained additional importance from the recent observation of their correlation with differences in the gonad and calcareous collar. In *C. saxicola* the gonadial tubes are large, club-shaped, and few in number (see Fig. 1, p. 214), while those in *C. normani* are relatively small, of even, cylindrical calibre, and very numerous. (See Fig. 2, for the faithful drawing of which I am indebted to Mrs. Orton, as well as for all the figures by which this paper is illustrated.) The gonad in the male and female in each of these forms is alike in its structure. The eggs of both species are about the same size, i.e. about ·4 mm. in diameter, but the sperm has not been examined closely.

VARIATION OF THE GONAD OF *CUCUMARIA SAXICOLA*.

The variation in the gonad of *Cucumaria saxicola* has been investigated in 50 adult specimens varying in size* from about 6 cm. to about 10 cm. in length. The gonad in adult *C. saxicola* consists of from about 10 to 60 club-shaped tubes (see Fig. 1, p. 214). These tubes vary in length from about 1 mm. to about 3·4 cm.: they are narrowest at the attached end, and vary somewhat in the degree to which the distal end is swollen (see Fig. 1), but at this part they are commonly 3 mm. in diameter. In any particular individual the tubes may vary greatly in size. The

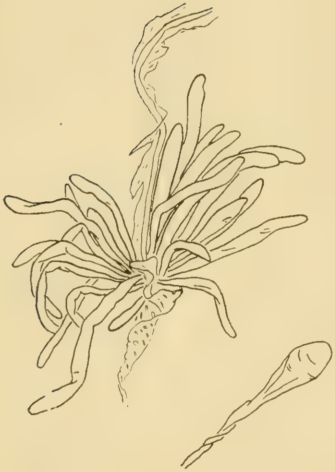

Fig. 1.

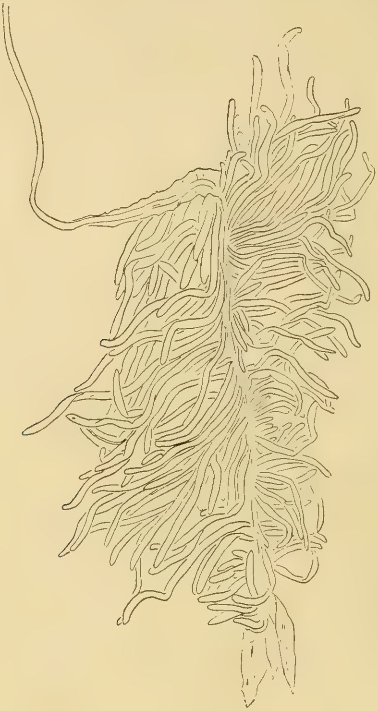

Fig. 2.

Fig. 1.—The gonad and gonoduct of *C. saxicola* B. and R. (Drawn *in situ*, $\times \frac{3}{2}$.) The single tube in the lower part of the figure on the right shows the shape of the tubes in this species better than those in the upper figure. This tube was taken from a male gonad, those in the upper figure constitute the whole gonad of a female.

Fig. 2.—The gonad and gonoduct of *C. normani* Pace. (Drawn *in situ* from a female specimen, $\times \frac{3}{2}$.)

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* These specimens were all measured when preserved, but as they were mostly well expanded the measurements may be regarded as roughly comparable.

tubes are arranged to the right and left of the mesentery supporting the alimentary canal in a position which is just behind the middle of the length of the animal. In this species the tubes join up at their attached ends to form a very short duct which unites almost immediately with its fellow on the opposite side to form the main gonoduct. The number of tubes on each side of the mesentery was noticed in all the specimens and recorded in columns 4 and 5 in Table 2 (see p. 215). It was found that the same number of tubes occurs only rarely on each side of the mesentery, but that there is generally about the same number: on the whole, however, more were found on the left than on the right side.

Table 2.—Illustrating the variation in the distribution and number of gonadial tubes in *Cucumaria saxicola* of different sizes.

Ref. No.	Approximate Length of Specimen.	Sex.		No. of Gonadial Tubes. On Left Side.	Right Side.	Total.
1.	6·0 cm.	♀ *		9	6+1 R.†	16
2.	6·0 ,,	♂	tubes full of sperm.	6	11	17
3.	6·3 ,,	♂		7	8	15
4.	6·4 ,,	♂		6+1 R.	12+3 R.	22
5.	6·6 ,,	♀		5+1 R.	3+1 R.	10
6.	6·6 ,,	♂	tubes full of sperm.	12+1 R.	8+2 R.	23
7.	7.0 ,,	♀	tubes up to 2·6 cm. long.	2+1 R.	12+1 R.	16
8.	7·0 ,,	♂		14	16	30
9.	7·0 ,,	♂		16	15+2	33
10.	7·0 ,,	♂		12	9	21
11.	7·0 ,,	♂	tubes full of sperm.	22	17	39
12.	7·0 ,,	♂		16	7	23
13.	7·0 ,,	♂		17+3 sm.	13+3 sm.†	36
14.	7·0 ,,	♀		8	10	18
15.	7·1 ,,	♂		14	8	22
16.	7·3 ,,	♀		4+2 R.	3+1 R.	10
17.	7·3 ,,	♂		12+4 R.	10+3 R.	29
18.	7·3 ,,	♀		9	9+1 R.	19
19.	7·4 ,,	♀		10	7	17
20.	7·4 ,,	♀		10+2 R.	7+1 R.	20
21.	7·4 ,,	♀		12	12	24
22.	7·5 ,,	♂		30+1 sm.	30	61
23.	7·5 ,,	♂		18	11	29
24.	7·5 ,,	♀		6	4	10
25.	7·8 ,,	♂		12	8	20

* Eggs in various stages of development were observed in the tubes of all the females.

† *R.* means a rudimentary; *sm.* a rather small tube.

Ref. No.	Approximate Length of Specimen.	Sex.		No. of Gonadial Tubes.		Total.
				On Left Side.	Right Side.	
26.	7·9 cm.	♀	very large tubes.	6+1 R.	6	13
27.	8·0 ,,	♀		8	10	18
28.	8·0 ,,	♂		8	9	17
29.	8·0 ,,	♂		13	16	29
30.	8·3 ,,	♀		13+1 sm.	12+1 sm.	27
31.	8·5 ,,	♂		6	7	13
32.	8·5 ,,	♀		13	15	28
33.	8·5 ,,	♀		13	13	26
34.	8·5 ,,	♂		21	28	49
35.	8·5 ,,	♀		15	18	33
36.	8·5 ,,	♂		29	23	52
37.	8·7 ,,	♀		7+1 sm.	7+1 sm.	16
38.	8·8 ,,	♀	tubes up to 3·0 cm. long.	13	14	27
39.	8·8 ,,	♂		14	15	29
40.	8·8 ,,	♀		10	13	23
41.	9·0 ,,	♂		11+3 sm.	11	25
42.	9·0 ,,	♂		12+12 sm.	14+12 sm.	50
43.	9·0 ,,	♀		12	10	22
44.	9·0 ,,	♂		11+1 sm.	11	23
45.	9·5 ,,	♀	tubes up to 3·4 cm. long.	16+1 R.	15+1 R.	33
46.	10·0 ,,	♂		16	21	37
47.	10·0 ,,	♀		7	12	19
48.	10·0 ,,	♀		8	4	12
49.	10·0 ,,	♀		12	8	20
50.	10·0 ,,	♂		14	12	26

A glance at the last column of Table 2 shows at once that the variation in number of the gonadial tubes in this species is distributed sporadically among individuals, and that the number does not necessarily increase with the size of the adult animal. Since the number of gonadial tubes is variable, it is of interest to examine the relative frequencies of the occurrence of any particular number. The frequencies of particular numbers, as, for example, of numbers between 10 and 15, and 16 and 20, and so on, have been plotted to give the curve in Fig. 3, p. 217. As, however, the number of individuals examined is small, the curve is less symmetrical than it would probably have been if a thousand specimens could have been examined. The ideal curve indicated by that in Fig. 3 would doubtless have one maximum in the region of 24 and 25, as indicated by the dotted line. Whether, however, the smaller crest of the curve (between 40 and 50) would become more important can only be found out by further investigation. The usual number of gonadial tubes in *C. saxicola* may therefore be fairly stated as 24 or 25. Curiously enough, about 25 is also the average number of tubes given for the whole of the 50 specimens examined. There is variation, however, in the number of gonadial tubes in this species between 10 and 61, as has already been observed.

It is an interesting fact that the males appear to be more variable in this respect than the females, although the small number of individuals examined necessitates caution in making this suggestion. Of the 50 specimens examined 24 were females and 26 males. The number of gonadial tubes in individual females varied between 10 and 33, whilst in the males the variation lay between 15 and 61. The total number of gonadial tubes in all the females was 477, giving an average of less than 20, while all the males gave a total of 769, giving an average of about 29·5.

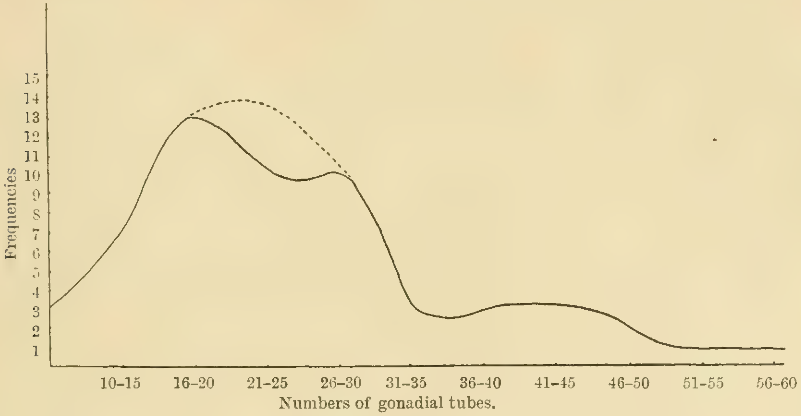

FIG. 3.—Curve showing the frequencies of different numbers of the gonadial tubes in 50 specimens of *Cucumaria saxicola* B. and R.

Ordinates=frequencies; abscissæ=number of gonadial tubes between 10 and 15, 16 and 20, and so on. The continuous line denotes the actual curve obtained, the dotted one an approximation to the form of the curve if a larger number of individuals were examined.

THE GONAD OF *CUCUMARIA NORMANI.*

The gonad of *C. normani* consists of a very large number of small cylindrical tubes of almost even bore. These tubes are arranged as in *C. saxicola*, on each side of the mesentery supporting the alimentary canal. The tubes on both sides open into one longitudinal collecting duct which extends in the mesentery some distance behind and in front of a point about the middle of the length of the body. This duct is continued anteriorly as the main gonoduct (see Fig. 2, p. 214). The largest individual tubes in a very fine specimen were found to be about 3·0 cm. long, and less than 1 mm. wide.

The number of tubes was counted for the purpose of comparison with those in *C. saxicola* in 6 individuals, of which 3 were males and 3 females. In these specimens, whose lengths were (1) 5·3, (2) 7·2, (3) 8·2, (4) 8·6, (5) 9·0, and (6) 12·5 cms., there were respectively 528, 582, 473, 513, 839,* and 250 tubes. A similar large number of tubes was, however, observed in all the specimens obtainable, namely, 30, of sizes similar to those given in Table 1. A comparison with similar specimens of *C. saxicola* from Table 2 indicates at once the great difference in this respect between the two species. The number in the specimen drawn for Fig. 2 was not counted. In this figure it may be mentioned that the tubes shown are chiefly those constituting the upper of several similar layers.

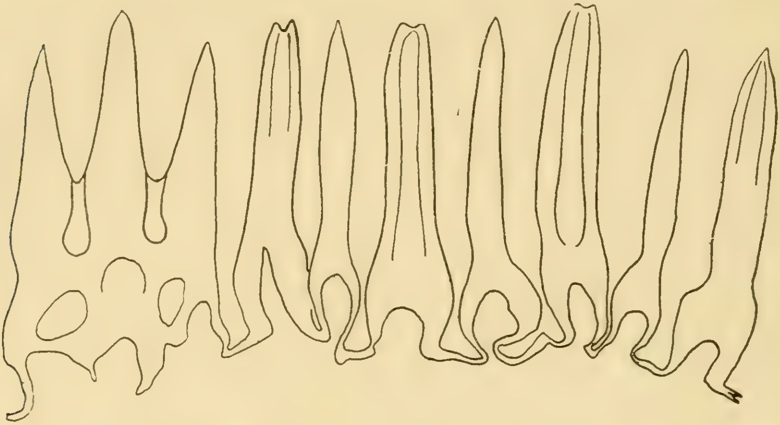

FIG. 4.—External view of the calcareous collar of *C. saxicola* drawn from a glycerine preparation after separating the ventral piece from the adjacent right radial piece ($\times \frac{20}{3}$).

It is an interesting fact that the examination of the gonad of even these few specimens of *C. normani* indicates a similar range of variation to that observed in *C. saxicola*, namely, that the males (numbers 1, 2, and 5) possess more gonadial tubes than the females (numbers 3, 4, and 6), that the number of these tubes is not necessarily larger in the larger individuals, and that within the species there is a wide range of variation in the number of the gonadial tubes, which may vary from about 250 to more than 800.

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* At least this number were present. Thirty-nine tubes which might have been broken were not added to the total.

The number of gonadial tubes was also counted in a few small specimens of *C. saxicola* and in one small immature specimen of *C. normani.* In specimens of the former of 3·8, 3·1, and 2·8 cms. in length, there were respectively 8, 4, and 6 small tubes, while in the specimens of *C. normani* of 3·3 cms. in length there were 199 tiny tubes.

It is thus evident that there is a marked difference between *C. saxicola* and *C. normani* in the characters of the shape and number of the gonadial tubes.

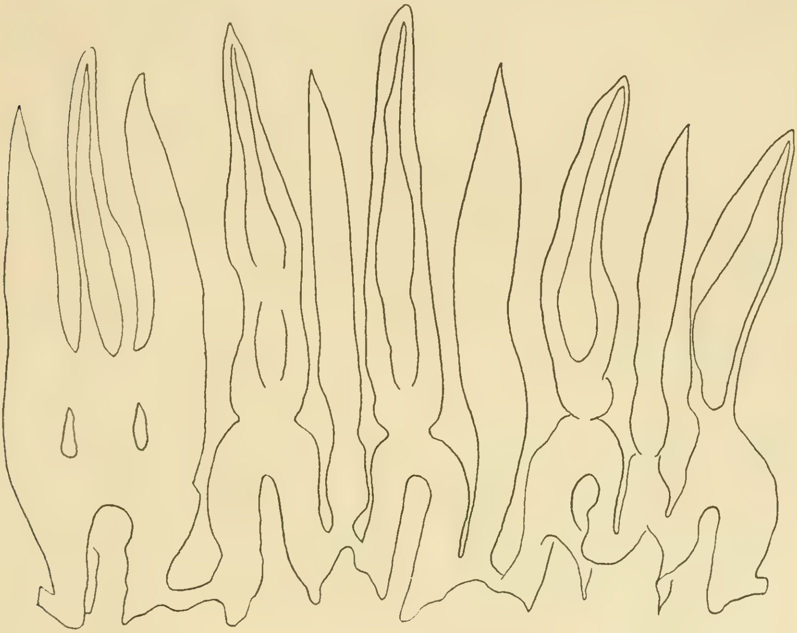

FIG. 5.—External view of the calcareous collar of *C. normani*, drawn from a glycerine preparation after separating the ventral piece from the adjacent right radial piece (× $\frac{20}{3}$).

CHARACTERS OF THE CALCAREOUS COLLAR OF *C. SAXICOLA* AND *C. NORMANI.*

The calcareous collars of both *C. saxicola* and *C. normani* consist alike of 5 radial alternating with 5 interradial pieces, and in both forms three of the ventral pieces, one radial and two interradials, are partially fused together. (See Figs. 4 and 5.) There is, however, a general difference in the relative stoutness of the collars in the two species, and some differences in the shapes and mode of connexion of the parts.

The collar of *C. saxicola* is relatively delicate, that of *C. normani* relatively stout. In specimens of the two species of about the same size, both the radials and interradials in *C. normani* are stronger, wider, and longer than in *C. saxicola*. (See Figs. 4 and 5.) In the latter species the interradials are deeply bifurcated at the posterior end (see Fig. 4), whereas in *C. normani* these plates are only slightly bifurcated (see Fig. 5), and the radials of *C. normani* differ from those of *C. saxicola* in being deeply constricted at the sides near the posterior end. Further, in *C. saxicola* there is a long narrow calcareous connecting loop between the radials and interradials, whilst in *C. normani* the similar connecting pieces are short and stout and produced posteriorly to a point. Hence the collar of *C. saxicola* is doubtless capable of much greater expansion than is that of *C. normani*. The shapes of these collars can be easily seen in preparations made by first soaking the anterior end of the animal in glycerine and afterwards dissecting away the surrounding tissue and mounting the collar in glycerine or glycerine jelly. This was found to be a better method than treating the collars with potash.

CHARACTERS OF THE SPICULES AND TUBE-FEET IN *C. SAXICOLA* AND *C. NORMANI*.

The characters of the spicules in *C. saxicola* have already been well described by Brady and Robertson (4). These characters have been confirmed by De Morgan (loc. cit.) and the present writer. They have also been found to co-exist with the characters of the gonad and calcareous collar given above for the species.

The spicules of the adult *C. normani* have also been well described and figured by Norman (2 and 3, Plate XI, Figs. 1, 2, 3, and 4) from his specimen labelled *A*. Spicules identical with these have been found to be correlated with a gonad consisting of a large number of small tubes and a calcareous collar as described above.

It is therefore only necessary here to point out the main features of difference between the chief kinds of spicules occurring in these two forms. The chief body spicule in *C. saxicola* is plate-like and rhomboidal in outline, having the opposite ends of one axis more or less produced. The central portion of the spicule is perforated by four holes, placed along the long axes and around the centre of the spicule. On the produced axis of the spicule one, two, or even three additional holes may be developed. In some individuals the holes on the shorter of the long axes are usually circular, while those near the centre on the long axis are more or less ellipsoidal in outline and larger than the former: in other individuals, however, the relative sizes of these foramina are reversed (see Brady and Robertson, 4, Plate LXXII, Fig. 3).

The chief body spicule in *C. normani* is also plate-like but ellipsoidal in outline; it has rarely more than four foramina, and bears on each surface usually 12 rounded bosses or nodules. The foramina are arranged diamond-wise along the long axes of the spicule. There are a great many more spicules in a given area of the body wall in *C. normani* than in *C. saxicola*, as may be easily seen in preparations of the skin: it is difficult to obtain exactly comparable specimens, but at a rough computation one would doubtless be well below the actual proportion in stating that they are twenty times more numerous in *C. normani* than in *C. saxicola*.

The surface body spicules in *C. saxicola* are well shown in Brady and Robertson's figure (4, Plate LXXII, Fig. 2). They are microscopic, stellate, of varying shape and size, but rarely more than 30 μ. wide, and scattered sparsely over the body. Usually they consist of a thin central plate from which radiate tiny cylindrical rods about 12 μ. long. On the other hand, the corresponding spicule in *C. normani* is bell-shaped, being slightly rectangular across the mouth of the bell, where on the average they measure about 40 μ. by 36 μ. These spicules are almost uniform in size, forming a continuous covering over the whole of the body and passing on to the bases of the tube-feet. Their compactness may be gathered from Fig. 8, which is a view through a low power of a microscope of a portion of the body wall of a small specimen in which, however, only one of the bell-shaped spicules is fully developed.

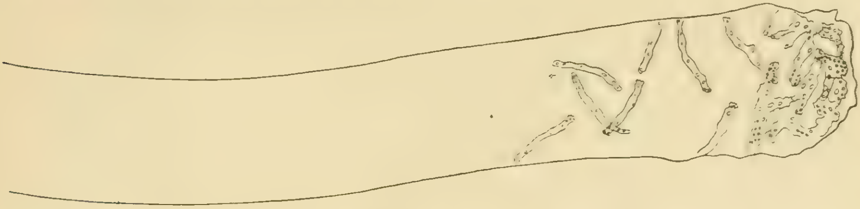

Fig. 6.—A single tube-foot of *C. saxicola*, showing the kind and number of the podial spicules (× about 30).

The podial spicules in *C. saxicola* are, as Pace has shown (loc. cit.), usually perforated with a single series of holes. These are well shown in Fig. 4, which is a drawing of a whole tube-foot well expanded (taken from specimen 45, Table 1). One of the microscopic surface spicules only is present. In *C. normani*, on the other hand, these spicules are mostly larger, and with two or more series of foramina (see Fig. 5, p. 219).

This figure is a drawing of a tube-foot of a specimen of *C. normani* 5·3 cm. long, taken from the right ventral ambulacral row—as was that of *C. saxicola*, shown in Fig. 6, p. 221. A comparison of these two figures, which may be regarded as typical, indicates the differences which occur in the podial spicules of these two forms. Those in *C. saxicola* are relatively few, mostly straight, with foramina in a single series, although there may be spicules with more than one series. Those in *C. normani*, on the other hand, are mostly broadly V-shaped, with foramina in two or more series: some spicules, however, are straight, with foramina in single series, as in *C. saxicola*. There are also a few bell-shaped surface spicules around the base of the tube-foot.

The difference in the relative number of spicules in these two forms is also well shown in these figures, and this difference is emphasized still more by the fact that not all the spicules in the tube-foot of *C. normani* could be drawn.

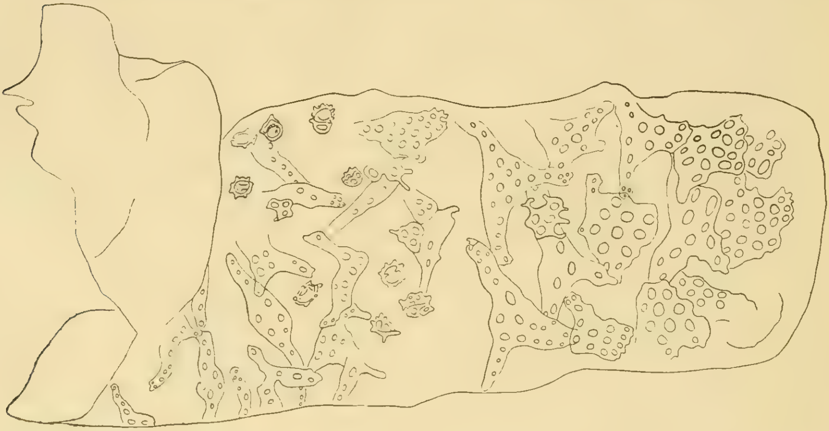

Fig. 7.—A single tube-foot of *C. normani*, showing the kind and number of the podial spicules (× about 65).[1]

DISCUSSION OF SOME FORMER OBSERVATIONS ON *C. SAXICOLA* AND *C. NORMANI*.

The establishment of undoubted specific and differential characters—given in the preceding pages—for these two species enables a partial clearing up to be made of the literature referring to these forms. Norman (3) in 1893 described three specimens, A, B, and C, of *Cucumaria* obtained at Polperro in 1865 as *C. montagui*. Subsequently Pace (1) in 1904 showed that one of Norman's specimens, A, was undoubtedly the same as the Plymouth species known at that time at Plymouth as *C. planci*, while the other two, B and C, were similar to the species known at that time at Plymouth as *C. pentactes.* After discussing the synonymy of Norman's *C. montagui*, Pace showed (1) that this name is a complex one, whose original form could not be traced, (2) that *C. planci* Brandt "cannot be applied to the very different species from Plymouth," and (3) that *C. pentactes* (Linnæus) "is now generally regarded as an indeterminate species." He therefore proposed to abolish all these names, substituting *C. normani* for the Plymouth *C. planci* and specimen A of Norman's *C. montagui;* and *C. saxicola* Brady and Robertson for the Plymouth *C. pentactes*, and B and C of Norman's *C. montagui*, which were shown to be identical with a species described in 1871 by Brady and Robertson as *C. saxicola.*

The researches here described support Pace's contention that Norman's *C. montagui* consisted of two species, subsequently named by Pace as *C. normani* Pace, and *C. saxicola* Brady and Robertson.

In 1905 Norman (2) wrote a paper maintaining his former views, which at this stage can be stated to be as follows: That he considered the Plymouth *C. saxicola* as the young of the Plymouth *C. normani* Pace, and that both were really equivalent to *C. montagui* Fleming. Norman's main contention in this paper is that the Plymouth *C. saxicola* are the young of the Plymouth *C. normani.* He, however, freely states that "When young specimens of *C. montagui*, say 14 mm. long, should be found having spicules agreeing with those of the adult, my view that B and C are young forms of that species would require to be reconsidered." In further support of his view Norman cited the known facts that spicules found in the young of some forms (for example, *C. frondosa*) disappear in the adult, and that spicules which in the young of some forms are smooth (for example, *C. hyndmanni*) become nodulous or thickened in older specimens.

The correlation of differences in the gonad and calcareous collar with the differences in the spicules described above is doubtless sufficient to establish the distinctness of these two species. Fortunately, however, tiny young ones of both species have been obtained, and so enable a comparison of both forms to be made throughout all stages of growth.

Besides these, however, De Morgan also obtained tiny *C. normani.* In his unpublished MS. he states: "I have examined specimens of both species from about one centimetre to three inches in length, both fresh and preserved in spirit, and find the plates that distinguish *C. normani* confined to *C. normani*; and those of *C. saxicola* to *C. saxicola.*"

Tiny specimens of *C. normani* were obtained by the writer from a floating raft moored in Cawsand Bay, just outside Plymouth Sound. These specimens measured about 13 and 14 mm.; in fact, just the size Norman wished for. These specimens were examined while living, and sketches made *from the living animal* of all stages of growth of the bell-shaped spicules.

Subsequently a preparation was made of the skin of these animals and a drawing of the spicules made *in situ* for Fig. 8, p. 225. This figure shows the different stages of growth of the bell-shaped spicules and also the degree in which these spicules are crowded in the surface of the skin. The young of *C. saxicola* have been reared by the writer from the egg to a size of about 5 mm., i.e. somewhat smaller than the tiny *C. normani* mentioned above. In these no bell-shaped spicules developed, although the body spicules were well formed. Specimens of all sizes of both species have been obtained from dredgings, forming a parallel series from the tiny ones mentioned above to the adults of sizes whose gonadial tubes and other correlated characters have been described. The evidence for the distinctness of these two forms is thus complete, whatever their ultimate names may be decided to be.

THE GROWTH-STAGES OF THE BELL-SHAPED SPICULES OF *C. NORMANI*.

The tiny specimens of *C. normani* mentioned above presented an opportunity of following the development of the bell-shaped surface spicules of this species. These spicules develop in four well-defined stages. In the earliest stage they consist of a microscopic plate forked at both ends (see Fig. 8 for this, as well as for the following stages). At a later period of development each of the forked ends divides dichotomously twice to give two succeeding well-marked stages. At the same time the central portion of the spicule becomes wider and thicker, and the growing arms arch outwards to form a hemisphere. At this stage one branch of each of the last-formed bifurcations grows towards a similar branch derived from the subdivision of the adjacent primitive prong. These branches grow together, but frequently become slightly forked again before fusing to form the rim of the spicule. The whole spicule at this stage becomes thickened, and generally two branches of the third order of division persist as projections at each of the four corners and one in the middle of each side of the rim when the spicule is fully formed. There are, however, sometimes variations from the general course. Occasionally three or five original prongs may develop and a three- or a five-rayed spicule is produced, at other times further subdivision of the branches of the third order occurs, giving rise to bell-shaped spicules slightly different from the usual form ; the normal form is, however, the one described above.

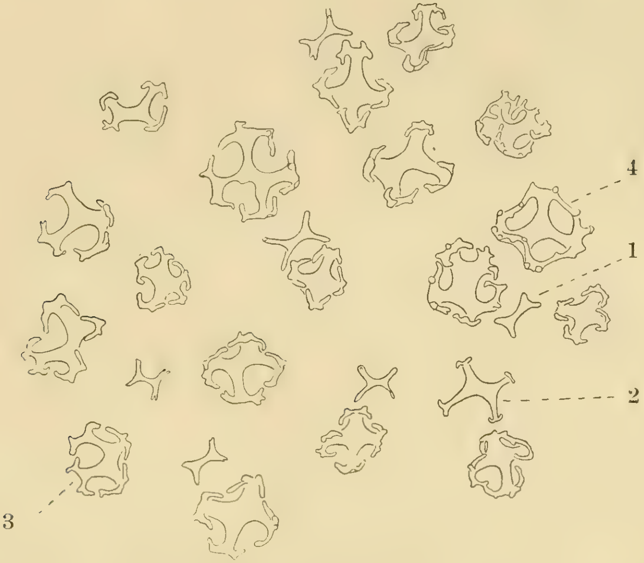

FIG. 8.—The campanulate surface spicules of *C. normani.* Drawn from a piece of the skin (mounted whole) of a specimen 13 mm. long to show a series of stages in the development of these spicules and their compact arrangement.* One fully developed spicule is depicted (× about 300).

THE SYNONYMY OF *C. SAXICOLA* BRADY AND ROBERTSON AND OF *C. NORMANI* PACE.

It will be evident from the foregoing accounts that the synonymy of the two species mentioned above may be expected to be and actually is in a highly confused state. This confusion has been rendered still worse by the fact that continental zoologists have regarded *C. montagui* as a good species, whereas it has been shown to be a complex one. Thus according as the one or the other constituent of *C. montagui* has fallen into the hands of these zoologists, the other constituent—on the Continent—has been given another name. There can be little doubt that the two species discussed in this paper do occur on the Continent, but at present pass under other names. It is therefore improbable that the literature on these Holothurians will be properly purged until some specialist can take the whole group into consideration and obtain and compare type specimens from the various authors and stations.

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* Drawings were made of some of these stages of development from the fresh living animal as a safeguard against their possible subsequent alteration in preservation. It was found, however, that the spicules in the mounted specimen agreed with the drawings from the living animal.

A few observations on the literature may, however, be useful. From the establishment of the complex nature of *Cucumaria montagui*, it seems highly probable that the earlier British naturalists were familiar with the constituents of the complex under the names of *Holothuria pentactes* and *H. pentactes* var. *montagui* Fleming. The descriptions of these animals are, as Norman has already pointed out (1905), insufficient to enable us to identify them. These names should therefore be abandoned on this ground if on no other. In 1828 Fleming (5) called *H. pentactes* var. *montagui* definitely *H. montagui*, but, as Pace (1904) pointed out, Fleming unfortunately based his description of this form on specimens which were obtained from the Firth of Forth and which may have belonged to another species. Thus we have no criterion as to what *Cucumaria montagui* really is.

In 1871 Brady and Robertson (4) discovered a species of *Cucumaria* in Westport and Birterbury Bays, Ireland, and gave a good description of the spicules. This species they named *C. saxicola*. In 1882 Barrois (6) found a species of *Cucumaria* at Concarneau on the shore which he called *C. lefevrei*. This species resembles that described by Pace (1904) as *C. normani* closely in the characters of its spicules (as described) and its calcareous collar. It is, indeed, highly probable that these are the same species, but it would be necessary to compare actual specimens of these forms to be certain of their identity. If, however, such were established Pace's name would have to give way to that of Barrois'. It should be pointed out that Barrois' figures do not agree with his description.

In 1889 Hérouard (7), having apparently never seen Brady and Robertson's description of *C. saxicola*, described a form apparently identical with the latter as *Colochirus lacazei* n.sp. It is a somewhat amusing fact that this writer was roundly accused shortly afterwards by Marenzeller (8, 1893) of wilfully renaming what he well knew was *C. montagui*. It is also of interest that Marenzeller—like Pace—states confidently in the same paper that *C. montagui* is quite and obviously different from *C. lefevrei* Barrois. Now Marenzeller's *C. montagui* were sent to him by Norman (2, p. 389), who definitely states they were like his specimens B and C, which have been shown above to be *C. saxicola*.

About the same time Ludwig and Hamann (9, 1892) state, but without giving a discussion, that *C. lacazei* Hér. =*C. lefevrei* Barrois. It is thus a curious fact that two pairs of men, one in England and one on the Continent, should hold independently similar conflicting views on what appears to be the same pair of species.

A little later Koehler (10, 1893), discussing the synonymy of *C. montagui* Fleming, gives as synonyms among others *C. lacazei* Hér., *Holothuria montagui* Fleming, and *Cucumaria pentactes* Bell, pointing out, however, at the same time that *C. montagui* differs from *C. lefevrei* in the shape and number of its genital tubes. He also figures spicules of *C. montagui* which are identical with those of *C. saxicola.* Now Koehler also received his specimens of *C. montagui* from Norman, who admits, as we have seen, that those sent were identical with his specimens B and C, i.e. with *C. saxicola.*

About this time Bell (11) added his quota to the confusion by giving as synonyms *Holothuria montagui* Fleming, *Cucumaria pentactes* Forbes, *C. elongata* Düb. and Kören. In 1902 Perrier (12) obtained *C. elongata* from the Gulf of Cadiz, and stated that this species is fundamentally different from *C. montagui:* he did not indicate, however, what were the characters of his *C. montagui.* Kemp (13) in 1905 described *C. elongata* Düb. and Kör. from Ireland and figured its spicules. Subsequently I obtained specimens of this species from various localities in this neighbourhood (see description on p. 229) from which there can be no doubt of the distinctness of this species.

From the foregoing historical account it appears that the complex, *Holothuria montagui,* of the older naturalists has subsequently been renamed as *Cucumaria saxicola* Brady and Robertson, *C. lefevrei* Barrois, *Colochirus lacazei* Hér., and *C. normani* Pace, as well as other names. Of these four names one pair, *C. saxicola* and *Colochirus lacazei,* seem to be undoubtedly synonymous; from the apparent identity in the characters of the spicules and genital tubes it is highly probable also that the other pair are synonymous. It is important, however, that these latter forms should be compared in actual specimens before making further alterations of names; hence until the whole of the European Cucumarians are revised by a specialist, the name *C. normani* Pace may be said to stand for that constituent of the old *C. montagui* whose characters are summed up in the foregoing pages.

CORRELATION IN THE CHARACTERS OF THE GONAD AND AMBULACRA IN THE GENUS *CUCUMARIA*.

The difference in the character of the gonad in *C. saxicola* and *C. normani* described in the foregoing pages suggested that similar differences might occur in other Cucumarians. On investigating the other species of this genus occurring in this district, it was found that they fall into two groups, having the following characters :—

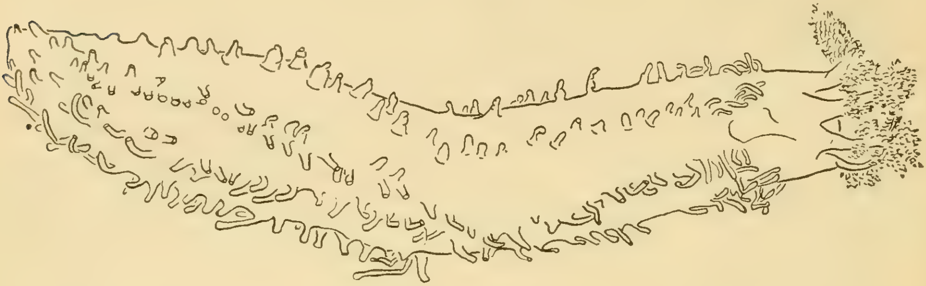

Fig. 9.—View of *Cucumaria saxicola*, showing the five ambulacral rows (× $\frac{3}{4}$). The view is mainly lateral from the right side, but the posterior end of the animal is turned somewhat dorsalwards to show in this region the three ventral ambulacral rows. These rows are seen to consist of suctorial tube-feet. On the upper right side of the figure are seen the two dorsal ambulacra, the right one of which is continued in profile to the posterior end of the body; both rows are seen to consist merely of ambulatory papillæ, except at the anterior end, where there are a few suctorial tube-feet.

Group A. Species whose gonad consists of numerous short cylindrical tubes, and whose dorsal as well as ventral ambulacra have well-developed tube-feet.

In this group fall the species *normani*, *hyndmanni*, *elongata*. (Compare Fig. 10, p. 230.)

Group B. Species whose gonad consists of relatively few, large, club-shaped tubes and whose dorsal ambulacra contain mostly ambulatory papillæ, which are less numerous than the tube-feet in the ventral rows, but with a few definite tube-feet at the anterior ends. (See Fig. 9, p. 228.)

In this group fall the species *saxicola* and *brunnea*.

Now the genus *Colochirus* differs in the literature (9, p. 343) from the genus *Cucumaria* mainly in having ambulatory papillæ in the dorsal ambulacra. It is possible, however, that when the gonad in species of

Colochirus is examined it may be found to be similar to that in *C. saxicola* and *C. brunnea.*

With regard to the Group B given above, it is an interesting fact that Norman himself (2, p. 382) states that some of his specimens (which have been shown to belong to *C. saxicola*) would be placed by some naturalists in the sub-genus *Colochirus* merely on account of the characters of the dorsal ambulacra, and also that Hérouard placed what is almost certainly *C. saxicola* in that very genus as *Colochirus lacazei.* It is not improbable, therefore, that when the European *Cucumarians* are revised the whole of the genus *Cucumaria* may be divisible into two groups similar to those given above, and that those specimens having the characters of Group B may have to be designated as species of the genus *Colochirus.*

PART II.

ON THE OCCURRENCE OF *CUCUMARIA ELONGATA* DÜB. AND KÖR. AND *THYONE RAPHANUS* DÜB. AND KÖR. IN THE PLYMOUTH DISTRICT.

During the period from March, 1911, to Sept., 1912, numerous specimens of *Cucumaria elongata* Düb. and Kör. were obtained at various stations in the Plymouth district. These specimens were nearly all taken in a dredge with a fine-meshed net, worked from the Laboratory steamer *Oithona.* The depths from which these *Cucumarians* were dredged varied from about 5 to about 30 fathoms, and the nature of the bottom in which they were living was almost invariably muddy, but varying from fine mud in Plymouth Sound and off Rame Head, to muddy gravel in the region about 2 miles south of Wembury Bay, and to fine muddy sand on the Rame-Eddystone Trawling Ground. (See 16 and 17.*) There can be little doubt that *C. elongata* is fairly common in this district on all the muddy grounds, and is probably not uncommon on the fine sand of the outer grounds.

The captures of this species have been made at 15 stations within a small area, so that the distribution can be described with reference to the various grounds already defined in earlier volumes of this Journal (16* and 17) as follows :—

Plymouth Sound. On one occasion (18th May, 1911) 4 specimens were taken in one haul of the dredge in the middle of Plymouth Sound, while on the date 23rd March, 1911, one specimen was obtained similarly in the same locality. Many unsuccessful hauls have, however, also been made.

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* See these references for a description of the grounds in the Plymouth district. Since those accounts were written in 1899 and 1904 there has been a good deal of mud deposited on the various grounds just outside the Sound from dredgings in the harbour.

Off Rame Head 6 specimens were taken in the dredge in mud about 1 mile south of the headland. Five of these specimens were taken in one haul of about five minutes' duration.

From the region of the Mewstone "Amphioxus" Ground, between and about the points 1½ to 2 miles south of the Mewstone and Yealm Point, captures of *C. elongata* were made in the dredge on seven different occasions. On the 3rd June, 1912, 12 specimens were obtained in about half a day's work with the fine-meshed dredge. In all, about 20 specimens have been obtained from this ground.

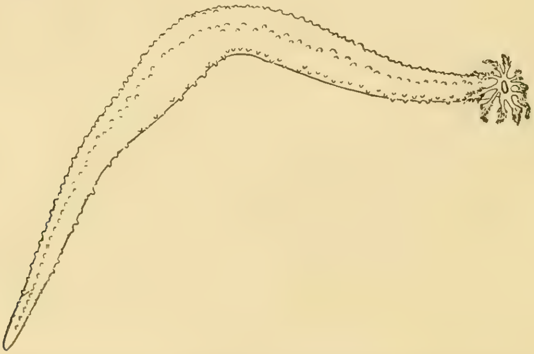

Fig. 10.—*Cucumaria elongata* well expanded, showing the tentacles and dorsal ambulacra (× 3/2).

Two specimens have been taken on different occasions on the Rame-Eddystone trawling grounds, both from a position about 5 to 5½ miles S. ½ E. of Rame Head.

The total number of specimens obtained from all the grounds is about 35. They varied in size from about 1·4 cm. long and 2·5 mm. broad to 6·6 cm. long and 9 mm. broad at the broadest part. The specimens when caught were U-shaped, or more or less S-shaped, with a tapering posterior end, and varied in colour from a purplish brown to a browny grey.

NOTES ON *CUCUMARIA ELONGATA*.

The discovery of this species in the Plymouth district is of some interest with regard to the unravelling of the synonymy of British *Cucumarians*. Bell in 1892 (11, p. 38) gives *C. elongata* Düb. and Kör.

as a synonym of *C. pentactes*, most of the specimens of which he records from Plymouth.

It has been shown in the foregoing pages that the Plymouth species called *C. pentactes* in 1892 is undoubtedly the same as Brady and Robertson's *C. saxicola*. This species is, however, totally different from *C. elongata* Düb. and Kör., as may indeed be gathered from the description of this animal given by Düben and Kören (14). Kemp (13) has recently given a good description of the external characters and spiculation of *C. elongata* Düb. and Kör. from Ireland. The Plymouth specimens agree well with Kemp's description and with that given by Düben and Kören themselves. There is thus no doubt that *C. elongata* is a good species and quite different from other Plymouth *Cucumarians*.

Some of the specimens obtained have been kept under observation alive for as long as nine months embedded in fine sand. In life the posterior end of the body, "the tail," protrudes above the surface of the sand presumably for the purpose of respiration. (Comp. Fig. 11.) The body is bent in a U- or S-shaped fashion as was observed in the freshly caught animal. During the whole of the period these animals were kept the tentacles have rarely been seen above the surface of the sand. It is possible, therefore, that the animal feeds mainly by ingesting mud or sand, as it is apparently much too sluggish to search actively for food. The tentacles in this species are very short, as may be gathered from Fig. 10, which is a drawing of a specimen narcotized by menthol. In this figure is well shown the double rows of tube-feet near the middle of the body and the gradual passage into single rows towards both the tapering ends of the body.

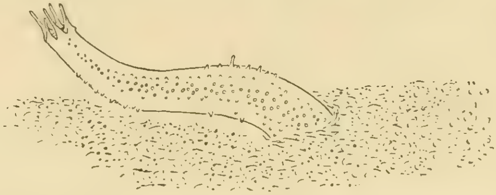

FIG. 11.—Drawing from life of the "tail" of *Thyone raphanus* protruding from the sand (× 4).

It has already been noted that the gonadial tubes of this species are numerous and cylindrical, resembling those of *C. normani* both in shape and approximately in numbers. The retractors of the buccal mass are extremely short and altogether poorly developed.

The gonads of female specimens taken in June and July were found to contain nearly ripe eggs; in July, 1912, a specimen was obtained with active sperm and an unsuccessful artificial fertilization tried. It is highly probable, however, that the species breeds a little later than this time of the year, as specimens taken in early May and September had only immature ova in the gonad.

ON *THYONE RAPHANUS* DÜB. AND KÖR.

Nine specimens of *Thyone raphanus* Düb. and Kör. were taken at various times between July, 1911, and July, 1912. These specimens were captured, except in one case, in the fine-meshed dredge in muddy sand or in muddy gravel in depths from about 12 to 30 fathoms. Four specimens were taken on one occasion 1½ to 2 miles S. of the Mewstone, and on another one specimen 1½ miles off Yealm Point. Two were obtained in July, 1911, about 3 miles S. of Rame Head, and two in May, 1912, in a position 5 to 5½ miles S. ½ E. of Rame Head. In the same month one specimen was taken in the trawl on the inner portion of the Rame-Eddystone trawling grounds.

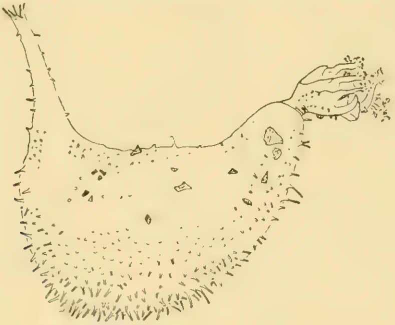

FIG. 12.—*Thyone raphanus.* The body portion was drawn from the living animal and the tentacles afterwards added from a preserved specimen (× ¾).

The specimens varied in size from 2·5 cms. long by 7 mms. wide at the widest part to 6·2 cms. long by 1·1 cms. wide, the measurements being taken from the preserved animals. Their general colour was of a creamy white, and when obtained from the dredge they were bent in the form of a U. In none of the specimens examined were ripe sexual products found, hence it is likely that breeding occurs during the winter months. The spicules from the skin, tube-feet, and tentacles agree closely with those given by Düben and Kören (14, Plate V, Figs. 49 to 55). There are, however, some spicules with bosses arranged concentrically around the foramina, but probably the Figures 50, 51, and 54 in the aforementioned plate are an attempt to represent these bosses. The calcareous collar is shown in Fig. 13, from which it will be seen that it is very similar to the portion figured by Marenzeller (18): the connecting pieces are not calcified in the smaller forms. The polian vesicle is single and very long, and longer in the larger than in the smaller specimens; in preserved specimens it may be dilated at the proximal or the distal end, or at both ends.

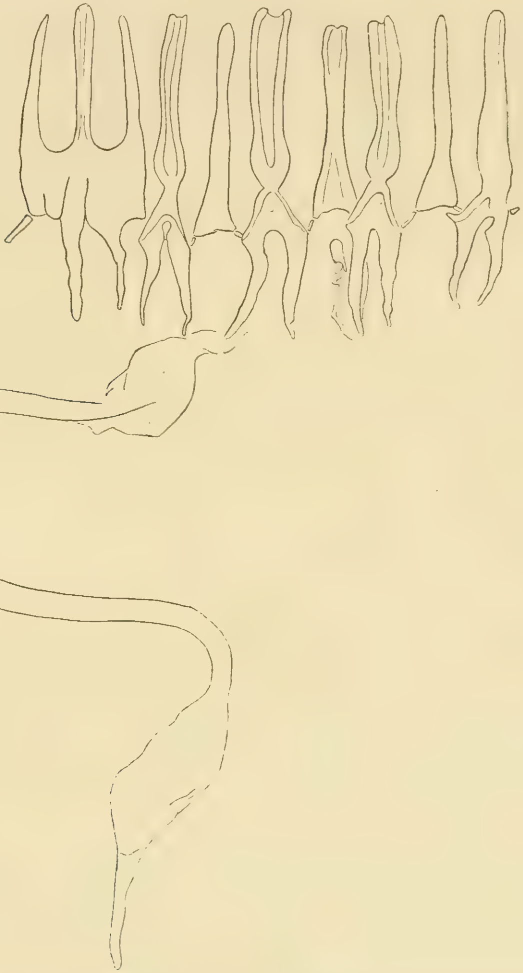

Fig. 13.—External view of the calcareous collar of *Thyone raphanus* Düb. and Kor. drawn from a glycerine-jelly preparation after separating the ventral piece from the adjacent right radial piece: the polian vesicle and the stone canal are shown attached to the collar* (× 9).

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* The constituent pieces of the collar are somewhat delicate, so that drawings from potash preparations are liable to be inaccurate, inasmuch as the middle portion of the radials is very thin and might easily be abraded to give such a figure as is drawn by Barrois for *T. poucheti* (loc. cit.).

It is unfortunate that Düben and Kören did not figure the calcareous collar and polian vesicle of the type specimens, for Barrois has described a form which only differs from *T. raphanus* in having a bifurcated polian vesicle. Neither of these authors, however, found more than one specimen. The Plymouth specimens agree with Barrois' form except in the calcareous collar as figured by Barrois and the presence of tube-feet on the "tail" (cf. 6, Plate I, with Fig. 11, p. 231, and Fig. 13, p. 233), and they agree also with Marenzeller's form except in the polian vesicle as figured by Marenzeller. As, however, Théel (19) had already doubted the distinctness of *T. poucheti*, it is very probable that all these forms belong to Düben and Kören's species *T. raphanus*. There is some ground for believing that Barrois' figure of the delicate calcareous collar of his Thyone is not a typical one; and Marenzeller's figure of a bifurcated polian vesicle requires confirming in more specimens. Therefore for the present it has been deemed advisable to refer the Plymouth forms to *T. raphanus* Düb. and Kör. If, however, the type of the latter species is found to possess constantly a bifurcated polian vesicle, then the forms from this district probably belong to *T. poucheti* Barrois.

Several individuals of this species were kept under observation alive for some months in the same dish with the *C. elongata* mentioned above. These specimens maintained their tails above the surface of the sand, as is shown in Fig. 11, in the same way as did the *Cucumarian*. The tentacles have, however, only been seen expanded above the surface of the sand on two occasions when the water was becoming foul, and it was observed that the body was maintained bent in a U-shaped manner. The tentacles in this species are very short (see Fig. 12), as in *C. elongata*. This reduction of the tentacles and buccal retractors and the correlated tailed posterior end are also found in the group Malpodiida, which also inhabit muddy situations and have been found to ingest the muddy sand in which they live (15). Doubtless these characters of the tentacles are related to the manner in which all these animals feed, for short stiff tentacles would be much more useful for ingesting mud or fine sand than the long dendritic tentacles such as are found, for example, in some other species of *Cucumaria* and *Thyone*. Thus these mud-dwelling *Holothurians* form one more example of that interesting phenomenon in nature, namely, the occurrence of similar adaptations in different animals for performing the similar functions necessitated by a similar mode of life.

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On Anthura gracilis (Montagu).

By

E. W. Sexton.

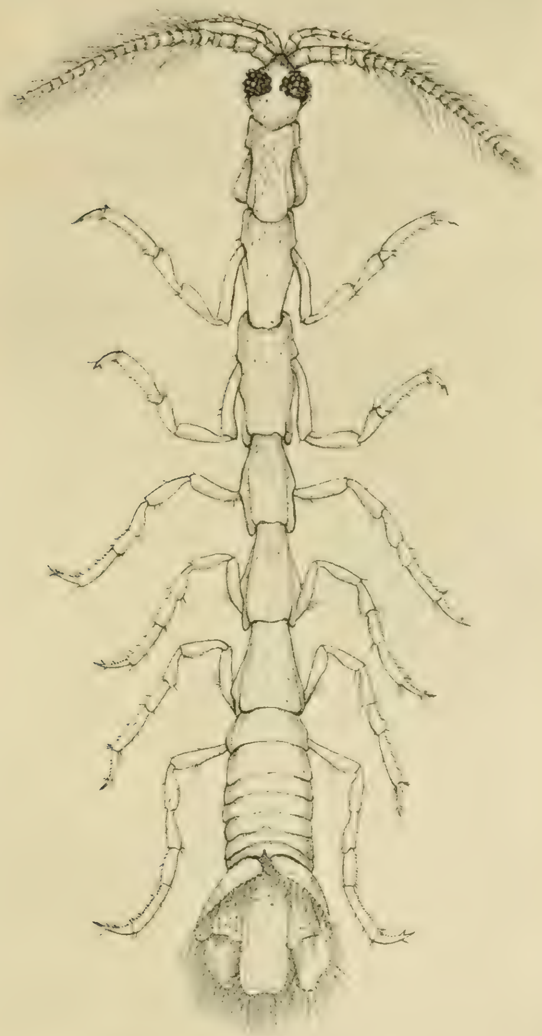
With 12 Figures in the Text.

On August 14th, 1913, a fine male specimen of *Anthura gracilis* was taken by the *Oithona*, in the young-fish trawl working at the surface at night, about six miles west of the Eddystone.

An excellent account of the female and young male has been given by Norman and Stebbing (*Trans. Zool. Soc.*, Vol. XII, p. 122), but, as far as I am aware, the adult male has never been described, and as it differs considerably in appearance from the female, I have figured it here, adding to Norman and Stebbing's description some notes made on the Plymouth specimens.

Female specimens are occasionally found in the dredgings from Plymouth Sound, but males are rarely captured.

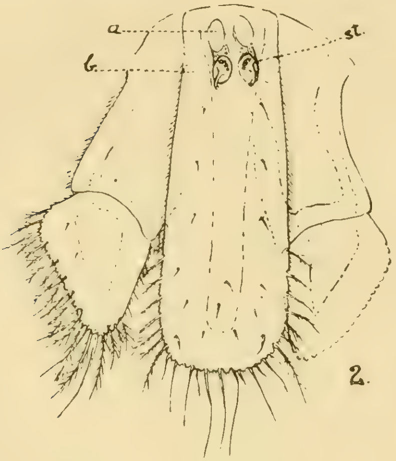
Very little is known of the habits of the species. The females are evidently much more sedentary than the males ; they are more heavily built, the body stouter, the mouth organs larger, and the first gnathopods much heavier and bigger than in the male (cf. Figs. 9 and 11). Stebbing, in his *History of Crustacea*, 1893, p. 335, makes an interesting suggestion with regard to these animals and their mode of life. In referring to the *Eisothistos vermiformis* of Haswell and its habit of living in the tube of a Serpula with its tail at the mouth of the tube, the uropods and telson mimicking in appearance the operculum and branchiæ of the worm, he says : " Probably the British *Anthura gracilis* may use a similar shelter, since it is undoubtedly dredged up in company with shells and stones on which the tubes of Serpulæ are abundant." An observation recently made by Mr. Crawshay (*Mar. Biol. Journ.*, Vol. IX, No. 3, 1912, p. 351) appears to support this suggestion, at least as far as the female is concerned. In the material trawled at forty-two fathoms he found one specimen of this species, a female, head inwards in a tube of *Sabellaria spinulosa*. He noted the position of the tail appendages lying nearly flush with the opening of the tube, and added : " Their appearance was so deceptive to the eye that they might easily be mistaken at a rough glance for the anterior region of the original occupant of the tube." On the other hand, it must be stated that an examination of several hundred tubes of *Sabellaria spinulosa* dredged in Plymouth Sound did not yield a single *Anthura*. The female specimens collected by the Laboratory have been generally found after the dredgings have been

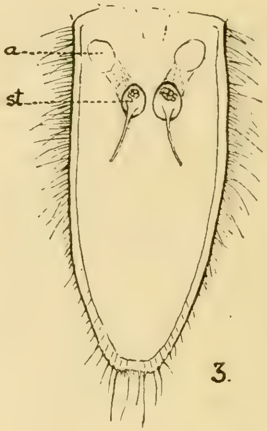


Anthura gracilis. FIG. 1.—♂, dorsal view. Eddystone specimen, × 17.

left standing for some time; as the water becomes foul the animals crawl out of the crevices and holes in which they have been hidden.

The males are very active. Mr. Clark, the naturalist on board the *Oithona*, says of the Eddystone specimen that when caught it darted about from side to side with quick jerky movements. This specimen is the largest male yet recorded, measuring 10 mm. from the tip of the rostrum to the tip of the telson. Of the three other males caught at Plymouth, one taken off Drake's Island measured 8 mm.; the other two recorded by Garstang (*Mar. Biol. Journ.*, Vol. II, p. 123) were 4 mm. and 5 mm. long and had 9 and 12 joints respectively in the flagellum of the upper antenna. A suggestion has been made that the male on reaching sexual maturity has an active but short life. I think the note just referred to helps to solve this question. These two small males had already reached sexual maturity, as shown by the development of the sensory setæ of the upper antennæ (a secondary sexual character appearing at maturity), but that they were not nearly full grown can be seen on comparison with the Eddystone specimen. The number of joints in the flagella increases with age. The Eddystone specimen—10 mm. in length—had 20 joints developed in the flagellum of the upper antenna, thus showing that the period of sexual maturity and activity had extended over a length of time sufficient to allow for several moults and the consequent considerable increase in growth.

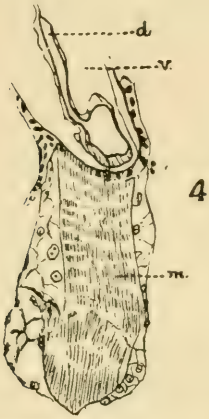




Anthura gracilis. Fig. 2.—Telson, ♀, × 42.
Cyathura carinata. Fig. 3.—Telson, ♀, × 42.
a, muscle attachment; *b*, muscle attachment, inner uropod; *st*, statocyst.

A very interesting point in this species is the presence of statocysts in both male and female. I am indebted to Dr. Calman for drawing my attention to the question of the existence of these organs in the Anthuridæ; to Dr. A. Thienemann for sending me some of the actual specimens referred to in his paper (*Zool. Anz.*, Vol. XXVI, pp. 406–410); and to Dr. Allen for his kindness in sectioning specimens of both *Cyathura carinata* and *Anthura gracilis*.

The species, of which the statocysts are so fully described by Thienemann, proved to be *Cyathura carinata* (Norman and Stebbing, *Trans. Zool. Soc.*, Vol. XII, p. 124) as suggested by Gurney (*Trans. Norfolk Nat. Soc.*, Vol. VIII, p. 433). I have figured the telson of both species for comparison.



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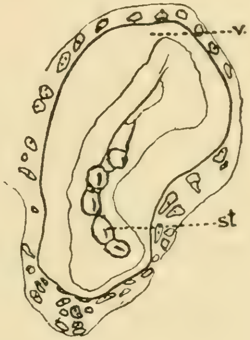

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Anthura gracilis. Fig. 4.—Horizontal section, upper part of statocyst on the right side, showing duct, × 100.

Fig. 5.—Horizontal section, lower part of statocyst on the left side, showing the crystalline bodies of the statolith, × 435.

d, duct; *m*, muscle; *st*, statolith; *v*, vesicle.

It will be seen that the general structure of the statocysts is exactly the same in both genera, but the details naturally vary a little. It is impossible to see these organs in specimens preserved in the usual way. Dr. Thienemann, in reply to a question as to whether they were to be observed in the living animal, said: "So viel ich weiss, waren die Organe am Lebenden *nicht* zu sehen; dagegen waren Sie sehr deutlich bei Aufhellung mit Nelkenol, Kreosot oder Zylol." Dr. Thienemann adds the interesting note that in two species of another genus of the *Anthuridæ* examined by him, viz. *Calathura brachiata* Stimps, and *C. norvegica* G. O. Sars, in Bergen Museum, no statocysts were found.

Each statocyst consists of an oval vesicle, lying embedded in the tissue of the anterior part of the telson, nearer the dorsal surface. A very fine tube or duct communicating with the exterior rises from the upper surface of the vesicle, on the side away from the median line (Fig. 4 *d*), while at the bottom of the vesicle, towards the median line, the crystalline bodies of the statolith can be seen (Fig. 5 *st*). A strong muscle is attached to the anterior wall of each statocyst; much stronger in *Anthura* than in *Cyathura*; it appears to be attached at its anterior end to the chitin of the telson. This attachment looks like a coloured oval body, and is as noticeable as the statocyst itself, seen *in situ* (Fig. 2 *a*), but an examination of the sections shows its construction. The two dotted bodies (Fig. 2 *b*) are similar muscle attachments in the inner uropods.

DESCRIPTION.

Body cylindrical, much more stoutly built in the female than in the male, with strongly marked longitudinal keels, three in the female, four in the male. In both sexes there is a dorso-lateral keel on either side, starting in the male just behind the eye, and finishing at the end of the peraeon, while in the female it runs the whole length of the body, from the tips of the lateral angles of the head to the end of the pleon. In both, also, the mid-ventral keel is well developed. The male has, in addition, on the head and peraeon, a smaller but well-defined mid-dorsal keel, most marked on the anterior segments.

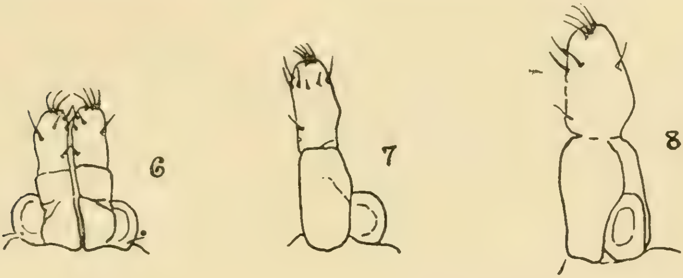
Pleon. In the female the first five segments are coalesced and equal in length to the last peraeon-segment, in the male these segments are distinct and equal in length to the two last segments of the peraeon.

Head in the female almost square, with a short rostrum and with the anterior lateral angles also produced and projecting a little further forward than the rostrum. In the male the shape is quite different, the front of the head from the eyes tapering gradually downwards to a strong obtuse rostrum (Fig. 1).

Eyes black, very prominent in the male, and of great size, occupying nearly half the surface of the head and almost meeting dorsally; ommatidia very large, distinct from each other, corneal facets convex, the whole eye resembling a blackberry. In the female the eyes are much smaller, round in shape, and flat, not prominent.

Upper Antennae in the female shorter than the lower antennae. The first joint of the peduncle is equal in length to the second and third taken together; flagellum two-jointed, consisting of one long joint without setae, and a minute terminal joint carrying a cluster of eight to ten setae of varying lengths, and three long sensory filaments. In the male the long flagellum reaches to the posterior margin of the second peraeon-segment, and consists of twenty joints in the Eddystone specimen (Fig. 1), the first joint short, the second constricted proximally and expanded distally. All the joints except the first are fringed with very long, delicate, outstanding setae, giving a brush-like effect to the antenna. The smaller male from Drake's Island had sixteen joints in the flagellum.

Lower Antennae. The second joint of the peduncle is greatly expanded distally; the third very small; fourth rather longer; the fifth equal in length to the third; flagellum in the female four-jointed, the terminal joint furnished with a thick cluster of long setae. The flagellum in the male is six-jointed, the first joint as long as the others taken together.



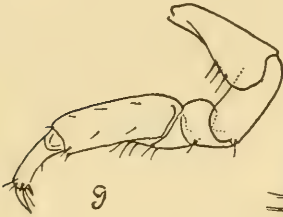
Anthura gracilis. Fig. 6.—Abnormal maxillipeds, ♂, Drake's Island specimen, × 75.
Fig. 7.—Maxilliped, ♂, Eddystone specimen, × 75.
Fig. 8.—Maxilliped, ♀, 10.5 mm., × 75.

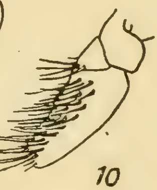
Mouth organs as described by Norman and Stebbing. They are larger in the female than in the male. The mandibles have a three-jointed palp; the falcate process terminates in three blunt teeth, the thin blade below with five serrations, the serrations more acute in the males examined than in the females.

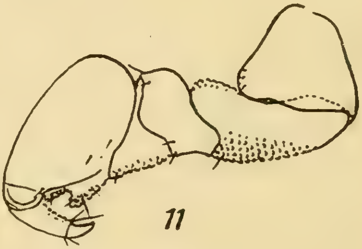
Maxillipeds. Palp one-jointed (Figs. 7 and 8) tipped with a row of four stiff slightly curved setae. In Fig. 6 the maxillipeds of another male are figured, showing an abnormality in that a second and very distinct joint is developed. The specimen was perfectly normal in all other particulars, but it serves to illustrate the danger of describing species from one or two solitary specimens.

Gnathopod 1. In the male the first and second joints are subequal, both produced distally on the upper side over the succeeding joint; third joint produced on the under side. The fifth joint or hand narrowly pyriform, widest proximally, tapering to the insertion of the finger, rounded above, and turned at a different angle to the rest of the appendage; palm covered on the under surface with long stout setae; finger carrying one small spine and a few setae distally; nail strong, curved.

In the female (Fig. 11) the gnathopod is much larger and stouter than in the male. The first joint is as broad as long, distally expanded; second joint slightly longer, furnished on both margins with a pectinate scale-like armature. This armature is also found on the anterior margins of the fourth, fifth, and sixth joints. The hand as described by Norman and Stebbing is pyriform, upper portion well rounded, palm with a well-developed process projecting forward near the base; inset on the under surface near the finger is a cluster of stout setae similar to those of the male.





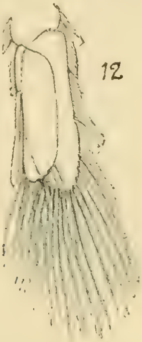


Anthura gracilis. Fig. 9.—First Gnathopod, upper surface, ♂, Eddystone specimen, × 42.
Fig. 10.—First Gnathopod, under surface, ♂, Eddystone specimen, × 42.
Fig. 11.—First Gnathopod, upper surface, ♀, × 42.

Gnathopod 2 and *Peraeopod* 1 alike in construction in both sexes. The first joint is longer than the second; third half the length of the first, strongly lobed posteriorly; fourth very small, triangular; fifth as long as the first, nearly parallel-sided, front margin finely pectinate, the microscopic spines arranged in semicircles giving the effect of overlapping pectinate scales down the whole length of the margin; two strong spines inset at the insertion of the finger. Finger long, finely pectinate, carrying one strong spine and some setae at the base of the nail, and two or three small spines proximally. Scattered over all the appendages are many mobile sensory hairs, each hair consisting of a shaft and a fine flagellum. These hairs are most numerous on the palm.

Peraeopods 2, 3, 4, and 5 alike in construction, a little shorter and stouter in the female. The first joint is slightly longer than the second; third and fourth shorter, subequal in length; fifth about the length of the first; finger two-thirds the length of the fifth. The first three joints are constricted proximally, the third lobed posteriorly. In all the peraeopods the anterior margins of the fourth and fifth joints are pectinate, the spines in the female being longer and more setiform in character; the finger also bears some small spines: two stout spines are inset together at the anterior distal angle of these joints, and a long plumose sensory hair at the posterior angle of the fourth joint. In the male the third joint of the fifth peraeopod is provided with two long sensory plumose hairs as long as the succeeding joint.

Pleopods 1 in both male and female, with the outer rami greatly expanded, forming a kind of operculum, reaching in the female to the extremity of the fifth segment of the pleon, in the male considerably beyond the end of the pleon. The modified second pleopod of the male is figured (Fig. 12).



Anthura gracilis. FIG. 12.—Second pleopod, ♂, × 42.

Telson and *uropods* as described by Norman and Stebbing, so constructed "as to resemble nearly a cylinder, with one side (the dorsal) cut obliquely away. The telson has the apex truncated, and is of the same length as the inner branch of uropods. Outer branches of uropods nearly meeting at their bases dorsally, broadly lanceolate, curved, rather longer than the first joint of the inner branch."

Colour, yellowish white, with markings of a brownish pigment in the form of cloudy patches. The colour varies considerably, probably with the nature of the ground on which the animal lives, some specimens—as the Eddystone one—having only a few small dotted patches on the head and peraeon, others again being nearly covered with the brown tint.

On *Leptonereis glauca* Clpde., and the Genus *Leptonereis* Kinberg.

By

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With Plate 1 in the Text.

INTRODUCTORY.

In February of this year Mr. J. H. Orton collected a number of small nereids on the piles of a wharf at the Great Western Docks at Millbay, Plymouth. These he kindly handed over to me for identification, and, along with other material collected at Plymouth in March, they form the basis of this paper.

These nereids proved to be none other than the little-known *Leptonereis glauca* of Claparède, of which the only specimen hitherto recorded from the shores of this country was found by Major E. V. Elwes at Oddicombe (8, p. 351) some years ago.

Claparède (3, p. 90) described the species from specimens obtained by him at Naples about 1870. He gives a good description and figures, but no particulars as to its numbers or habitat. It was next met with by de St. Joseph, who found it commonly in dredgings at all depths on the coasts of Dinard (6, p. 246) in 1888. This authority described his specimens as a distinct species, naming it *L. vaillanti.* (I shall show later that the two are identical.) He observed also the male and female heteronereids, of which he gave excellent and detailed descriptions, with a number of figures.

Thenceforward, *L. glauca* was not met with so far as has been recorded, until 1909, when Major Elwes found his specimen, a male heteronereid, at Oddicombe.

In 1878, however, Langerhans (5, p. 279) had described under the name of *Leonnates pusillus* another small species of nereid which, as I hope to show, is very closely related to, if not identical with, the one under consideration. This species he found at Madeira, and he observed in an aquarium the change to the heteronereid form in both sexes.

There can be little doubt that *Leptonereis* must occur commonly in many localities on the shores of this country and of the Continent in which its presence is not suspected, either for lack of observers or on account of its small size.

GENUS *LEPTONEREIS* KINBERG, CHAR. EMEND.

Proboscis furnished only with soft papillæ.

The notopodium and neuropodium rather deeply divided.

In the male heteronereid, the body is divided into three distinct regions, the middle region only being modified for swimming, while the posterior is marked by the appearance of peculiar fused setæ, not present in the nereid-form or in the female heteronereid.

Characters otherwise as in *Nereis* Lin.

Leptonereis glauca Claparède, Plate I, Figs. 1–10.

Leptonereis glauca Claparède, 3, p. 90, Pl. 7, Figs. 3–3*c*.
,, *vaillanti* de St. Joseph, 6, p. 246, Pl. 10, Figs. 113–123; Pl. 11, Fig. 124.
,, *vaillanti* Elwes, 8, p. 351.
,, *vaillanti* McIntosh, 8, p. 264, Pl. 86, Figs. 9–9*a*.
? *Leonnates pusillus* Langerhans, 5, p. 279.

This little nereid occurs in some numbers on the piles of the wharf at the Great Western Docks. These are exposed at low water, and are covered with compound ascidians, sponges, various cœlenterates and other sedentary organisms, which, together with the muddy sediment which accumulates in such places, form a thick encrustation on the cement piles and wallings near low-water mark. In these congenial surroundings *Leptonereis* dwells. It also occurs in dredgings from Asia Shoal and the Cattewater, in the former of which localities the bottom consists of stones and mud, in the latter of soft mud.

Its small size and the resulting difficulty of distinguishing it from other small nereids, no doubt account for its having been hitherto overlooked. The short cephalic lobe, stout squat palpi, and short tentacles, peristomial and parapodial cirri, and peristomium, serve to distinguish it —once its appearance is known—from *Nereis pelagica*, small examples of which occur in the same localities, but for certainty the parapodia and proboscis must be examined under the microscope.

Several dozens of specimens in all were collected, and a number of these were examined in detail, as a basis for the following description.

The length of the individuals ranges from 7 mm. to 35 mm., but the majority are about 25 mm. long.

As to colour, I examined live specimens from all three localities, and these were practically colourless, except for blood-vessels and gut showing through the semi-transparent body-wall. In examination some months later, however, some specimens (preserved in alcohol) show a slight band of brownish granular pigment across the dorsum of each segment, becoming more marked towards the posterior end of the animal. This band of pigment is more or less continuous with glands which occur on the base of the parapods, rather like those of *N. dumerilii*.*

Specimens of average size have 55 to 60 pairs of parapods ; the greatest number noted was 66, the smallest, in a specimen barely 9 mm. long, 35 pairs.

The body is fairly stout, tapering gradually towards the posterior end. There is a tendency towards shortness in all the appendages. The general form will best be realized by a glance at the figures, which are taken from typical specimens (Plate I, Fig. 1).

These worms, when placed in spirit, usually die with the proboscis retracted, but I succeeded in preventing its retraction in about a dozen specimens, obtained during my stay at Plymouth, by means of a pin pressed behind the head while spirit was poured over the creature. (This immensely facilitates the examination of small nereids.) The proboscis is short and stout ; the maxillary division is quite smooth, but the basal division possesses on the ventral side a row of 5 to 9 minute, soft, conical papillæ, perfectly colourless, in a transverse, even-spaced row towards the anterior margin. These correspond in position to paragnaths of groups VII, VIII. On the dorsal surface of the basal division a single larger papilla of similar nature (corresponding to VI) exists on each side. These papillæ are small and very inconspicuous. It is very difficult to distinguish them at all except when seen in profile, or when the light upon them falls at a suitable angle. Fig. 1 shows in profile the two outer papillæ of the ventral row.

Neither Claparède nor de St. Joseph observed any trace of such papillæ in the specimens from Naples and Dinard, but the Plymouth examples agree so completely otherwise with those, that one is inclined to think that the papillæ must have escaped observation in the other cases.

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* Later, in December, 1913, Mr. Orton kindly sent to me at Cambridge a number of living specimens from the Great Western Docks. In the living state these were of a dull orange tint over most of the body, due to the internal organs showing through the transparent body-wall. Towards the anterior end there was a slight dull greenish pigmentation of the skin, strongest on the head and adjacent segments, but hardly noticeable in most specimens. This pigment is shown up more clearly just after fixation when the body has become opaque.

Their presence, of course, rather upsets the characterisation of the genus, which has hitherto been based solely on the total absence of paragnaths or papillæ !

A remarkable feature was exhibited by a number of specimens collected on 20th March. These bore on the proboscis four patches of a jet-black colour, radiating outwards from the bases of the jaws, in the everted proboscis, towards the areas where groups II and IV of the paragnaths would, if present, occur. These black marks appeared to consist of a deposit of opaque pigment beneath the cuticle. Fig. **1** is taken from a typical specimen, and shows the two dorsal patches. Of twelve specimens collected on this date, eight showed these patches strongly developed, while the remainder exhibited no trace of them.

The black marks were still present when the specimens were re-examined after lying for some weeks in alcohol and formol, but by October, 1913, all traces of them had disappeared. Fortunately, however, one specimen had been mounted in balsam at the earlier date, and in this (the specimen figured) the black is perfectly preserved. Further investigation of its nature is desirable. The only other specimens which I examined in a fresh state had the proboscis inverted ; the rest of the material had been lying in spirit for some months.*

The parapodia of *Leptonereis* have been described in detail by St. Joseph, but I have thought it useful to figure these again, as they are the chief means of identification. (St. Joseph's figures are rather grotesque.†) They do not differ from the typical nereis-form of parapod except in that their noto- and neuropodia are more deeply and widely separated than usual. They are approximately similar from end to end of the body. The noto-cirri are rather short, usually slightly overreaching the ligule ; a slight increase in relative length of the cirri usually takes place in the posterior half of the body.

The setæ, which have been figured by Claparède, St. Joseph, and McIntosh, have the typical nereid arrangement, thus :—

Notopodial bundle, homogomph spinigers.

Upper neuropodial bundle { homogomph spinigers (above).
heterogomph falcigers (below).

Lower neuropodial bundle { heterogomph spinigers (above).
heterogomph falcigers (below).

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* The everted probosces of more than a dozen of the living specimens received in December, 1913, showed on examination no trace of these black patches.

† Claparède's single figure of a parapod is also unnatural.

St. Joseph (6, p. 247) notes that from the 13th to the 4th last segment, the spinigers of the notopodial bundle are replaced by others, similar, but with a much longer terminal appendage. This appears to be the case, too, in some at least of the Plymouth specimens, although the change seems to occur posterior to the 13th segment. I have not paid much attention to this point. He also states that homogomph as well as heterogomph spinigers occur in the lower neuropodial bundle. This I have not found to be the case.

Among the material collected by Mr. Orton on 25th February is a male heteronereis, apparently in the fully developed condition, and two other males at earlier stages of development.

St. Joseph (6) has described both the male and female heteronereid forms in detail. Claparède did not meet with either.

The above-mentioned male agrees very well with St. Joseph's description. It is 12·5 mm. long, with 58 pairs of parapodia. The noto-cirri of the first seven pairs of parapodia are much swollen (Fig. 7). The change to the swimming-parapod occurs between the 14th and 15th pairs (St. Joseph found it to occur between the 15th and 16th pairs—the variation is unimportant). In the 43rd to 45th pairs a transition towards the form of the third region occurs, the cirri and lobes becoming shorter and smaller, and the paddle-setæ decreasing in number.

The third region may be reckoned as commencing at the 44th pair, where the peculiar, large, simple setæ, figured by St. Joseph, commence. These are from one to three in number, and continue till the last setigerous segment. They are, I believe, to be regarded simply as derived from normal heterogomph falcigers by the fusion of the appendage with its socket. Ground for this belief is afforded by the analogy of the large bristles which occur in the posterior regions of *Nereis pelagica* and *N. agassizi*. In these the appendages are in some cases completely free, in others totally fused with the shaft.

Several females of the nereis-form, obtained on 20th March, were filled with ova. These are of very large relative size (0·24 mm. diameter).

The synonymy at the head of this section requires some explanation.

St. Joseph in his detailed and excellent account of *Leptonereis vaillanti* never refers to the possibility of this species being identical with Claparède's. He does not indicate any points of difference between the two species, and indeed, the only mention he makes of *L. glauca* is to say that the setæ of *vaillanti* are exactly similar to those figured by Claparède for the Mediterranean form.

Comparison of the descriptions and figures published by these two authors leaves us with the following points of difference :—

(*a*) The Dinard specimens differ slightly in colour.

(*b*) Their noto-cirri are shorter.

The general form of the head and its appendages, the proboscis and jaws, the peristomial cirri, the parapodia (except for the noto-cirri), the setæ, the dimensions of the whole animal and number of segments—all are identical in the two.

As to the points of difference, (*a*) hardly amounts to more than the fact that the Mediterranean specimens were more strongly pigmented than those from Dinard. The Plymouth ones, it appears, are still less so.

Then coming to (*b*) one may note that the noto-cirri of the Plymouth specimens are almost intermediate between those of St. Joseph's and those of Claparède's. It does not seem that much importance should be attached to this point.

Secondly, I have come to the conclusion that Langerhans' *Leonnates pusillus* from Madeira is at least very closely related to Claparède's *Leptonereis glauca*. Langerhans' description and figures leave no doubt that the two species are of the same genus (in view of the presence of papillæ on the proboscis to *Leptonereis*). In *Leonnates pusillus* a papilla is present in area II on each side, in addition to those on the basal ring (these are only visible " bei sehr genauem Zusehen "). Also the peristomial segment apparently was distinctly longer than in *Leptonereis glauca*. Many examples showed a large yellow spot on the cephalic lobe ; this, however, was not always present.

In other respects *Leonnates pusillus* is identical with *Leptonereis glauca*. Langerhans kept some specimens in captivity for some time and witnessed the change to the heteronereid form, in both male and female. His observations on these agree essentially with St. Joseph's. The large, brown setæ appeared in the same way in the posterior eleven pairs of parapodia of the male.

Langerhans concludes his description of this species with the suggestion that an examination of fresh material will show that in species such as *Leptonereis glauca* and *L. cebuensis* the proboscis is furnished with papillæ similar to those of *Leonnates pusillus*. After a lapse of thirty-five years his prediction has been fulfilled.

HISTORY AND SYSTEMATIC POSITION OF THE GENUS.

Kinberg (2, p. 179), in 1865, " created " the family Niconidea to contain those nereids in which the proboscis is devoid of papillæ, whether hard (paragnaths) or soft.

This family contained three genera, distinguished thus :—

Parapodia	uniform		*Nicon.*
	changing	gradually	*Leptonereis.*
		abruptly (with 3 changes)	*Nicomedes.*

In these three genera he enumerated eight species, all new to science, from the east and west coasts of South America, and from Tahiti. None of these species is described in sufficient detail to be recognisable, and only one is figured [(1, Taf. XX, Fig. 7), *Leptonereis lœvis*, n.sp., from Guayaquil].

Claparède (3, p. 90) united Kinberg's three genera under the name of *Leptonereis*, which he ranked as a sub-genus of *Nereis*, Linn. s. str. He chose the name *Leptonereis* on account of its convenience as a sub-generic name, and because it was the only one of the three genera which Kinberg had figured.

Claparède did not further characterise *Leptonereis*, but apparently simply accepted Kinberg's definition of the " family " Niconidea, namely, total absence of paragnaths or papillæ from the proboscis. Further he described *Nereis* (*Leptonereis*) *glauca*, a new species of which he apparently found several specimens in the Gulf of Naples, although in his "Annélides Chétopodes du Golfe de Naples" he gives absolutely no information as to its occurrence or habitat. He also figured the head and anterior segments, proboscis, a parapod, and setæ (most of his figures are good, although a little " artificial " in appearance).

In 1878 Grube described *L. cebuensis* from the Philippine Islands, and in the same year Langerhans published his account of *Leonnates pusillus*. Ten years later St. Joseph brought out his account of the annelids of the coasts of Dinard.

Grube and St. Joseph both followed Claparède in regarding *Leptonereis* as a sub-genus of *Nereis*, but McIntosh ranks it as a separate genus, differing from *Nereis* Lin. in the absence of paragnaths and in the deeply divided rami of the parapodia.

My own view, based on the examination of a large amount of material in all the groups of the genus *Nereis*, and in *Leonnates* and *Leptonereis*, is that the last-named should be ranked as a genus distinct from both the others. These three genera are, however, more closely related to one another than to any of the remaining genera of Nereidæ (i.e. Lycastis, Ceratocephale, Tylorrhynchus, Dendronereis, and Micronereis).

SURVEY OF THE GENUS *LEPTONEREIS*.

For generic characters (emended) see above, p. 245.

1. Leptonereis glauca Claparède, 1870.
   L. vaillanti, de St. Joseph, 6.
   Range : English Channel.
2. Leptonereis pusillus Langerhans, 1878.
   Leonnates pusillus Langerhans, 5.
   Very closely allied to the preceding species, if not identical (see above, p. 249).
   Range : Madeira.
3. Leptonereis cebuensis Grube, 1878.
   Grube's description of this species is unfortunately not accompanied by any figures.
   Range : Philippine Islands.
4. Leptonereis lævis Kinberg, 1865.

This species must remain rather uncertain, as Kinberg's description is very brief. The figures of anterior region and proboscis, a parapodium, and the setæ, are fairly good. The palps and tentacular cirri are longer than in *L. glauca*.

Range : Guayaquil (Ecuador).

[Kinberg did not figure any of the other seven species which he described under the genera *Nicon* and *Nicomedes*, and his descriptions are so brief as to be of little value for purposes of identification. The only one of these which has been met with again is *Nicon loxechini*, from the Straits of Magellan. In this case Ehlers has employed the name *Nereis loxechini* Kinberg for a species of which a single small specimen was collected by the German Deep-Sea Expedition at St. Paul Island (38° 40′ S., 77° 38′ E.), in the southern Indian Ocean. Ehlers unfortunately does not figure this specimen, nor does he describe it fully, so that there is considerable doubt as to whether it should be assigned to the genus *Leptonereis*. The *Nereis eugeniæ* Kinberg of Ehlers, although founded on Kinberg's *Nicon eugeniæ*, is a true *Nereis*.]

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EXPLANATION OF PLATE.

Leptonereis glauca Clap. Plymouth, 1913.

Fig. 1. Anterior region, with proboscis extended, ×23.
,, 2. Posterior extremity (from above), ×23.

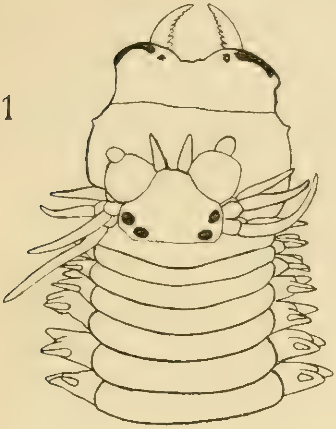
Figs. 3–5. *Parapodia of immature form.*

Fig. 3. 2nd R., anterior view, ×25.
,, 4. 12th L., anterior view, ×25.
,, 5. 34th L., anterior view (total 59 pairs), ×25.

,, 6. 41st L. (♀ nereid with ova), anterior view (total about 60 pairs), ×25.

Figs. 7–10. *Male Heteronereis.*

Fig. 7. 5th R., posterior view, ×35.
,, 8. 30th R., anterior view, ×47.
,, 9. 48th R., posterior view (total 58 pairs), ×35.
,, 10. Neuropodium from the posterior region, showing one of the large fused setæ half-grown, not as yet projecting from the parapodium (posterior view), ×145.



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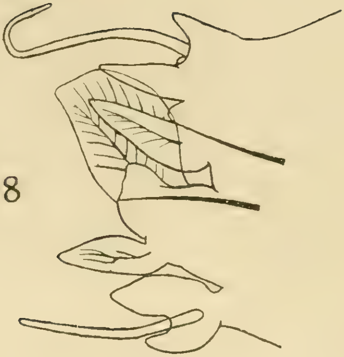

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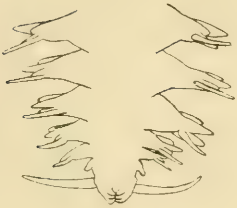

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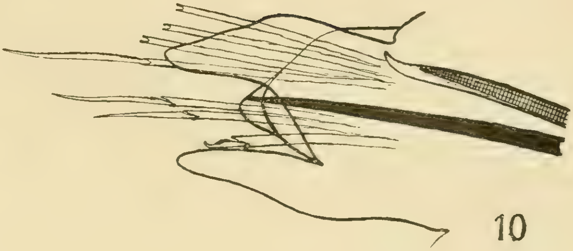

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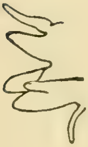

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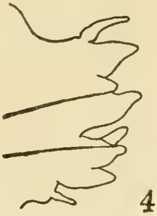

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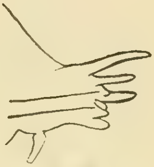

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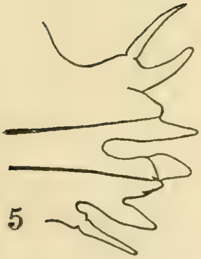

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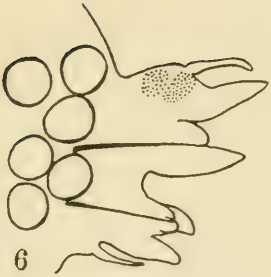

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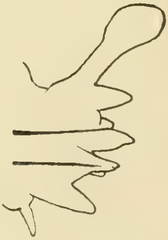

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L.N.G.R. DEL.

On the Breeding Habits of *Echinus miliaris,* with a Note on the Feeding Habits of *Patella vulgata.*

By

J. H. Orton, B.Sc., A.R.C.Sc.

With One Figure in the Text.

WHILE on shore-collecting expeditions in this district it was frequently observed that *Echinus miliaris* has the habit of associating together in pairs, and sometimes in groups of more than two.* The association of these pairs and groups is sometimes so intimate that it is not possible to interpose even the blade of a penknife between the interlocking spines of the urchins. In all cases observed except one, such pairs were placed side by side, but in one particular case the apical region of one individual was almost certainly placed adjacent to the apical portion of the other. In all the collecting expeditions†—made at various times of the year between April and August—on which groups were collected, the total number of urchins of all sizes obtained amounts to about 710. Among this number were obtained 84 groups, which amount in all to 189 specimens. In the earlier part of the investigation a group was taken as such if the members were merely fairly close together, but afterwards only those specimens were recorded which were actually touching one another in the manner described above. Out of the total of 84 groups only 27 were actually recorded definitely as touching one another, although some of the other groups may have been touching. Of these 27 closely associated forms *all the individuals were ripe* except 3 small specimens belonging to two pairs which were recorded as having an immature gonad. The remainder consisted of 19 pairs ♂♀, 2 pairs ♀♀, 1 pair ♂♂, and 3 groups respectively ♂♀♀,‡ ♂♂♀, and ♂♀♂♂. These facts in themselves point to the conclusion that in *E. miliaris* there is a distinct instinct for association of individuals at the time of sexual maturity, and that the association frequently, but not always, results in pairing of the sexes. In this respect the position in which two of the above pairs of male and female were taken is specially interesting. Both pairs were situated under a large stone whose lower surface was somewhat rectangular, and would measure rather more than two feet on the longer axis. The pairs were on the opposite ends of the lower surface near the edge of the stone on the long axis, and each member of a pair was closely opposed to the other. It would thus appear that these four urchins had definitely mated in pairs.

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* In a few cases as many as from 13 to 21 individuals have been found close together under one stone.

† In the search for groups of these urchins I am much indebted to the laboratory fisherman, William Searle, for the zeal and care with which he helped in the collecting.

‡ In this group the ♀ associated with the male was almost certainly spent, although it was difficult to make certain whether on the other hand it might be immature. Hence it is not grouped with the definite pairs of male and female.

Of the 57 remaining groups taken, 41 contained all ripe individuals, and combining these 41 groups with those given above, it was found that out of the total of 66 associations of ripe specimens, 41 were ♂♀, 9 of various sexes, 8 ♀♀, 6 ♂♂, and 2 ♀♀♀. Thus in all the groups of ripe forms there were 40 pairs of opposite sexes and $8+6+2=16$ groups exclusively of one sex or the other. Therefore, leaving out the 9 groups containing various sexes, it is seen that the number of pairs, namely 41, is greater than twice the number of the groups which contain one sex or the other. Consequently it is highly probable that the statement that the sexes of *E. miliaris* associate definitely for the purpose of breeding is significant.

In the whole of the groups collected, regardless of ripeness of the gonad in all the members of the group, there were 47 pairs of ♂ and ♀, 15 pairs ♀♀, 6 ♂♂, 8 groups of more than two containing both sexes, 2 groups ♀♀♀, 1 ♂♂♂, and 5 containing one or more immature forms. In the groups recorded as not all ripe there were some specimens quite ripe. Many of the other urchins in these groups, however, would probably have yielded some embryos if their sex cells had been mixed with those from similar forms of the opposite sex, but an attempt based on experience was made to name those forms ripe which would probably have yielded a good proportion of segmenting eggs as a result of fertilization. In this branch of the investigation I am indebted to Mr. H. M. Fuchs for some help in determining the state of the gonad.

A more significant result could doubtless be obtained by an examination of a larger number of pairs of *E. miliaris* obtained about the same time and during the breeding season, but the opportunities for such an investigation are not very common. *E. miliaris* can often be taken in numbers by dredging, and then I have frequently observed that many individuals are taken matted together, and in such a way as to suggest they were actually in that condition before being captured by the dredge.

In the same way large hauls of *E. esculentus* and *E. acutus* and relatively* large hauls of *Echinocardium cordatum* can frequently be made on certain grounds in hauls of not more than 10 to 15 minutes, but it is equally uncertain here, as in the case of the dredged *E. miliaris*, that there is any association in pairs; nevertheless it is not improbable that the aggregation of such large numbers of individuals might be in part for the purpose of spawning, since such hauls may be taken when all these species are ripe.

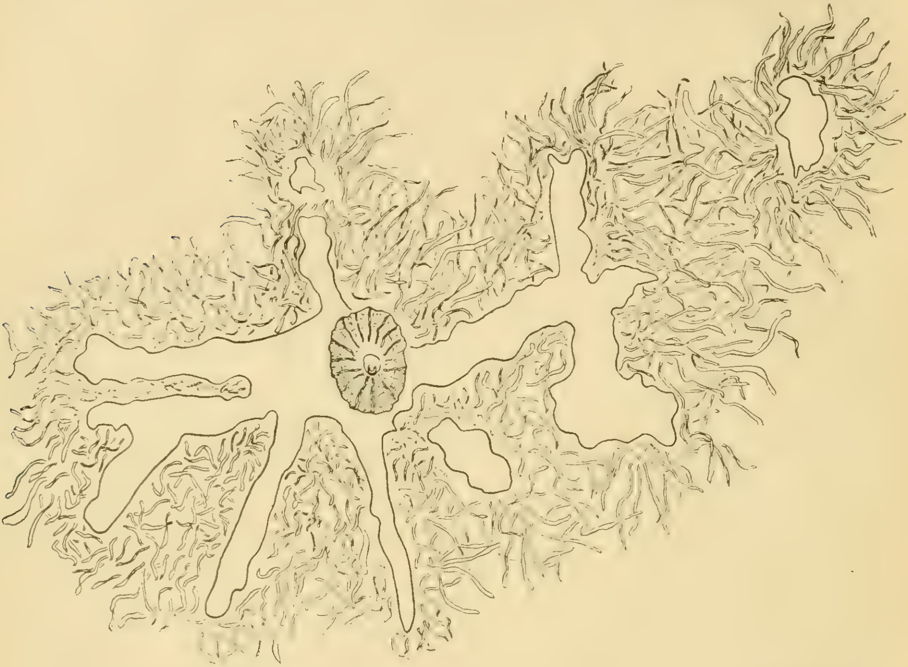

FIG. 1.†—A view of Patella showing the food-paths it has eaten in a growth of green algæ, chiefly young Enteromorpha ($\frac{4}{5}$ natural size).

The limpet is shown on its "home," from which it has made excursions in various directions and to which it has afterwards returned.

Tennent has observed‡ in Toxopneustes that "when these animals are ready to spawn they gather more or less closely together," and Hertwig* mentions that "egg-deposition may provide sexual stimulation to the males, since when a large number of urchins are placed together in sea-water as soon as the females begin to discharge eggs the males spawn." It is not improbable, therefore, that association of the sexes for the purpose of spawning may be common throughout the Echinoids.

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* *Echinocardium cordatum* when living in deep water inhabits fine sand, from which it can only be captured by means of a dredge, and in a 3-foot dredge a short haul may sometimes yield as many as 15 individuals. This species occurs in great numbers in the Sálcombe estuary within a very small area, but this aggregation is probably due more to the presence of only a small area of suitable ground than to a desire of the individuals to associate. Nevertheless in this locality these heart-urchins associate closely in groups of twos, threes, and sometimes in larger numbers. The sexes of the members of such groups have not, however, been observed.

† I am indebted to Mrs. Orton for the drawing for this figure, which has been copied from a sketch made in my collecting book.

‡ D. H. Tennent, *Journ. Exp. Zool.*, Vol. IX, No. 4, p. 659, 1910.

Note on the Feeding Habits of Patella.

It is well known that Patella obtains its food by browsing on both the smaller and larger forms of algæ.† Striking evidence of this fact has, however, been obtained and is worth noting. In observing specimens of Patella situated on cement piles above low-water mark, it was noticed that the animals had in many cases eaten away paths in the green algæ, chiefly young Enteromorpha, by which they were surrounded. The paths radiate from the "scar" of the animal, and are marked with fine lines made by the teeth on the radula. These paths are shown in Fig. 1. In several cases the animal had travelled beyond the end of the path formerly eaten before beginning to browse again, and afterwards returned home to its scar. (See Fig. 1.) Such configurations as that shown in the figure are by no means uncommon on the pier walls in this district in situations favourable for the growth of algæ. As the alga grows the food-paths of the limpet may become more marked, and in some cases the spatting of *Balanus balanoides* along the paths makes them so evident that they are easily seen from some distance away.

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* O. Hertwig, *Zeit. für Wiss. Zool. Jen.*, Vol. XXIV, p. 282, 1890.

† J. R. Ainsworth Davis and H. J. Fleure, *Patella L.M.B.C. Memoir*, Vol. X, London, 1903.

On the Occurrence of *Aphroceras* (*Leucandra*) *cliarensis* Stephens near Plymouth.

By

Arthur Dendy, D.Sc., F.R.S.

In July, 1912, a paper was published in the *Proceedings of the Royal Irish Academy* (Vol. XXXI) on the Marine Porifera of Clare Island, by Miss Jane Stephens, in which the authoress gives an excellent account of a new species of Calcareous Sponge, *Leucandra cliarensis.* In April of the same year I happened to be working at the Marine Laboratory at Plymouth, and my friend Mr. Orton brought me several specimens of a very pretty little calcareous sponge just collected by him at Wembury Bay. I was too much occupied with other work to examine these carefully at the time, but simply preserved them in spirit. Recently I have examined them in detail, and find, curiously enough, that they belong to the species described by Miss Stephens from Clare Island on the west coast of Ireland.

It is unnecessary, in view of the description already published by Miss Stephens, to give a detailed account of the sponge in this place. I may, however, point out the salient features by which it is easily recognized. The external appearance is characteristic. The individuals are usually solitary and less than an inch in height. The form of the sponge, however, varies greatly, from quite slender to almost globular. There is usually a single terminal vent. The surface, when viewed under a pocket-lens, exhibits a glistening appearance, with longitudinal striations due to the presence of gigantic oxea in the dermal cortex. This arrangement of the large oxea brings about a close resemblance to species of the genus Ute. The canal system is, however, typically leuconoid, with small, rounded flagellate characters.

The most remarkable and constant specific character appears to be the presence of enormous sabre-shaped apical rays on the gastral quadriradiates, sometimes reaching a length of 0·5 mm., and, of course, projecting into the gastral cavity.

In our recently published paper on " The Classification and Phylogeny of the Calcareous Sponges, etc." (*Proc. Zool. Soc. Lond.*, Sept., 1913) Mr. Row and I have placed the species in the genus *Aphroceras* Gray, which is distinguished from Leucandra by the presence of a dermal layer of gigantic longitudinal oxea. This genus cannot, however, be very sharply separated from Leucandra, and in *A. cliarensis* a great many of the large oxea lie obliquely in the deeper parts of the sponge, as in many Leucandras. Nevertheless, there are sufficient of the large oxea in the dermal layer to give the surface of the sponge the longitudinally striated (and not obviously hispid) character of Aphroceras.

The discovery of this interesting species at Plymouth contributes an interesting addition to the marine fauna, not only of the district, but also of Great Britain ; while the fact that it should have turned up there so shortly before the appearance of Miss Stephens' memoir is one of those curious coincidences which so frequently surprise the systematic zoologist.

Note on Two Unrecorded Plumularian Hydroids from the Plymouth Area.

By

James Ritchie, M.A., D.Sc.,

Royal Scottish Museum, Edinburgh.

CONFUSION has reigned in the works of British authors as to the relationship between *Plumularia catharina*, Johns., and a more simple form, with unbranched stem, found, like the former, on many parts of the coast. Johnston and Hincks, and the majority of their successors, have recorded the simple form, where it was thought worthy of mention, as a "stemless variety" of the former; but examination of the type specimens of *P. catharina* in the British Museum has proved that a fundamental distinction exists between the two forms.* *P. catharina* is a branched species and bears on each side of a hydrotheca *a pair of lateral sarcothecæ;* the other is a branchless, bristle-like form, bears on each side of a hydrotheca *a single lateral sarcotheca*, and has been long known as *Antenella* (or *Plumularia*) *secundaria* (Gmelin).

One of the most common of *Plumularias* in the Plymouth area, in a wide sense, is *P. catharina*, and in a recent paper† Mr. Crawshay records the "creeping variety" from many stations in the Outer Western Area of the English Channel, with the remarks that it occurred over the whole area, and that it was perhaps the most frequent of the two varieties, and was certainly the most flourishing in point of growth.

I have had the opportunity, thanks to Mr. Crawshay, of examining a few samples of the simple form, and find that it embraces two distinct species, which are different from *P. catharina*, and have not been recorded from the area. The most common of these is *Antenella secundaria* (Gmelin), distinguished by a simple stem, and by details of hydrotheca structure exceedingly like those of the erroneous figure of *P. catharina* given by Hincks in "British Hydroid Zoophytes," Plate LVI, Fig. 2*a*. It was found at Duke Rock in August, 1895, and was dredged in the

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* See Ritchie, "Note on the Type Specimens of *Plumularia catharina*," etc., *Proc. Roy. Physical Soc.*, Edinburgh, Vol. XIX, 1913, p. 1.

† Crawshay, *Journ. Marine Biol. Association*, Vol. IX, 1912, pp. 279 and 330.

Outer Western Area of the Channel at Station 37 (S. 41° W. of Eddystone at distance of 17·1 miles) in 1906.

The other species is *Antenella siliquosa* (Hincks), described by Hincks, from St. Peter's Port, Guernsey, in 1877,* and since recorded from only two areas: from S.W. of Toulon at a depth of 445 metres, and in the neighbourhood of Roscoff on the N.E. corner of France between 60 to 80 metres (Billard, 1907 and 1912). To these localities Plymouth material adds two more records, both in the Outer Western Area of the Channel. A few colonies were obtained from Station 80, S. 16½° W. of Eddystone, 48·9 miles distant, at a depth of 51 fathoms; and a larger clump was dredged during Cruise VII at an undefined position between S. 17° to 27° W. of the Eddystone, at a depth between 49 and 53 fathoms.

The two species may be readily distinguished. Both have simple unbranched stems. *A. secundaria* closely resembles *P. catharina* in the details of structure, but has only one sarcotheca flanking each hydrotheca, in place of a pair; *A. siliquosa* has a wider and larger hydrotheca, but its distinctive feature lies in the lateral sarcothecæ, which occur one on each side of a hydrotheca, and have the even margin of the terminal section interrupted by a large wide embayment, a condition not recorded from any other species of *Antenella*.

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* *Ann. Mag. Nat. Hist.*, ser. 4, Vol. XIX, 1877, p. 148, Pl. 12, Figs. 2–6.

On *Alcyonium pulmonis instar lobatum* Ellis.

By

R. Hartmeyer, Berlin.

With one Figure in the Text.

In the year 1755 Ellis described in his "Natural History of the Corallines," as "*Alcyonium pulmonis instar lobatum*," a "sea production" from Whitstable, which the fishermen there had brought to him under the name of "Sea-Fig." As regards the systematic position of this form, he expresses himself only in so far as to place it with the Alcyonians, a group in which were united at that time, along with true species of Alcyonium, Ascidians, Hydroids, Sponges and even Algæ. As a doubtful synonym of his species Ellis put forward the *Pulmo marinus* of Rondelet (1555), which however has nothing whatever to do with it and indeed cannot be certainly determined. During the following years, Ellis' work was translated into several languages. A Dutch and a French translation, both dating from the year 1756, are known to me, the former by Tak, the latter by Allamand. There is also a German translation by Krüniz dated 1767.

Before I proceed with the history of this species it appears to me advisable first of all to define it, so as to be able in the further course of the discussion to deal with a fixed systematic conception. The description and the figures which Ellis gives are so characteristic that the "*Alcyonium pulmonis instar lobatum*" can only be identified as a compound Ascidian. As such the species was recognised, as soon as ever the close relationship of the colony-forming ascidians, which had previously been regarded as Alcyonians, to the simple ascidians was determined, that is to say about the year 1816. It is remarkable however that the form has never since been the subject of a thorough description, although it is mentioned in many textbooks and handbooks, as well as in faunistic papers, during the following 30 or 40 years. In more recent literature the species receives scanty mention, mostly only as a list name or as an uncertain species, whilst it has practically entirely disappeared from the most modern literature.

My wish to clear up if possible once for all this form by the examination of typical local examples has now been carried out through the kindness of Dr. Allen. I received three colonies sent by him, which had been collected by fishermen at West Mersea, Essex, that is to say in a locality which from a faunistic standpoint can hardly be different from the neighbourhood of Whitstable. Especially valuable to me was however the accompanying information that the name "Sea-Fig" has been retained there down to the present day. We have therefore every right to suppose that these specimens from West Mersea are the same species as the "*Alcyonium pulmonis instar lobatum*" of Ellis.

An examination of these three colonies has yielded a result which I had previously anticipated: Ellis' species is no other than the well-established *Macroclinum pomum* (Sars), which is frequently mentioned in the most recent literature and is everywhere common in the North Sea. This supposition must have already forced itself upon the mind of anyone acquainted with the species, when reading Ellis' description, a model of its kind, and comparing it with his figures. After the direct proof of the occurrence of *Macroclinum pomum* on the Essex coast no further doubt of the identity of the two forms would seem to be possible.

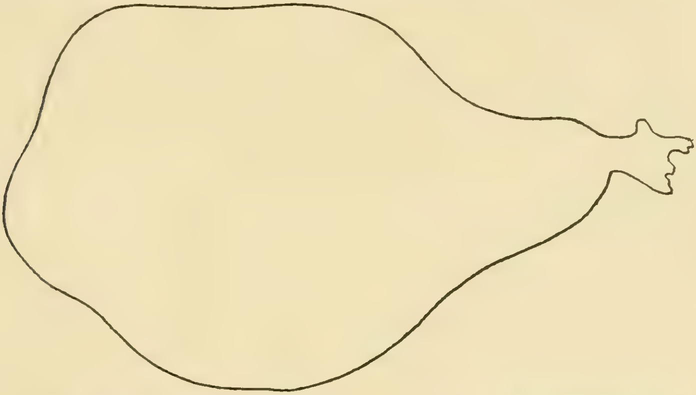

Fig. 1.—*Macroclinum pulmonaria* (Ell. Sol.). Colony from West Mersea. Natural size.

Of the three colonies before me from West Mersea, the largest has a typical fig-like shape. The anterior end is broadened, the posterior end is tapered and runs out into a quite short, stem-like process, which serves for its attachment. The colony is strongly compressed laterally. Its length is 7·9 cm., its greatest breadth 5·1 cm., whilst its thickness never exceeds 1·1 cm. The colour is greenish grey. The systems are not very clearly recognisable, but are undoubtedly present. The whole habitus of the colony with the separate individuals shining through like yellow seeds, is very aptly characterised by the description "Sea-Fig." A second colony is considerably smaller. The length is only 3·4 cm., the breadth 2·7 cm. The posterior end is less strongly tapered, the remaining characters are on the other hand the same. Finally the third colony forms only a small cushion on a sponge.

So much as to the material in hand and the identity of Ellis' form with the *Macroclinum pomum* of recent literature. In order to establish the synonomy and the correct specific name I will now proceed to the history of the species, which is specially complicated by the fact that in the old literature for many decades the species was confused with a sponge, which to-day in sponge-nomenclature bears the name *Ficulina ficus* (Pall.). Ellis and Solander (1786) first pointed out this error, and Esper (1806) also recognised it, but Lamarck (1815) was the first and after him Lamouroux (1816) to distinguish the two species by special binomial names.

Ellis' "*Alcyonium pulmonis instar lobatum*" reappeared for the first time in the literature in Pallas, in his "Elenchus Zoophytorum" of the year 1766, and indeed as a synonym of *Alcyonium ficus*. The specific name *ficus* was here for the first time used in a binomial combination with the generic name *Alcyonium*, so that Pallas must be regarded as the author of that species which must bear the name *ficus*. The following extracts from the literature relating to the synonymy of *Alcyonium ficus* are quoted verbally :—

(1) *Alcyonium tuberosum forma ficus.* Imper. ital. p. 599 lat. p. 839. Only the Italian edition of the "Historia naturale" of Francesco Imperato dated 1599 has been available to me. A form is there described and figured on p. 734, under the name "*Alcyonio tuberoso in forma di fico frutto: Alcyonio quinto di Dioscoride,*" which is without doubt a sponge and has been identified by the spongiologists as *Ficulina ficus*. I do not know whether the page reference given in the Italian edition, namely page 599 in Pallas, is due to an error, or whether it refers to some other edition. A date of publication for Pallas is not given. Moreover the same page reference is found in Esper. In the latter's work the quotation from Imperato (Esper writes Imperati) reads: "*Alcyonium tuberosum forma Ficus: Halcyoneum quintum Dioscoridis.*" I will take this opportunity of mentioning that the "*Alcyonio quinto di Dioscoride*" quoted from *Imperato* is mentioned in his Materia medica of the year 1478 as "*Alcyonii quinta species.*" A determination of this form is hardly possible.

(2) *Alcyonium tuberosum.* J. Bauh. hist. III p. 817. In the "Historia Plantarum universalis" of Joh. Bauhin and Joh. Henr. Cherler dated 1651 there is in *v.* 3 lib. 39 p. 817 a copy of the figure from Imperato, with the description *Alcyonium tuberosum.* This reference also must be assigned to the sponge.

(3) *Ficus substantia inter Spongiam et Alcyonium mediæ.* Marsil. hist. mar. p. 87 tab. 16 n. 79. This reference is to the "Histoire physique de la Mer" by L. F. Marsilli dated 1725. The passage there reads exactly: "*Figue de substance d'Eponge & d'Alcion, nommée par Trionfetti, Alcyonium tuberosum, forma ficus Imperati.*" The coasts of Barbary are given as locality. This reference also, as may be seen from the figure, t. 16, f. 79, without doubt has to do with a sponge and *Ficulina ficus* is indicated. A copy of this figure is to be found also in Esper (1806).

(4) *Alcyonium quintum antiquorum.* Mercat. metall. arm. 6. c. 6. p. 102. In his "Metallotheca Vaticana" dated 1717 Mercati describes, under the title "*De quinto antiquorum alcyonio,*" a form which is also a sponge and must be regarded as a synonym of *Ficulina ficus.* The figure bears the legend "*Alcyonium quintum.*"

(5) *Pulmo marinus alter Rondeletii.* Raj. syn. p. 31. n. 3. In the 3rd Edition of his "Synopsis methodica Stirpium Britannicarum" dated 1724, J. Ray puts forward the *Pulmo marinus alter Rondel.* as a synonym for *Bursa marina.*—Rondelet's species cannot be determined. The *Bursa marina* is on the other hand an Alga. The reference from Ray does not therefore come into consideration either in connection with the sponge or the ascidian. In the first edition of this work dated 1690, which Lendenfeld (1896) quotes, I do not find "*Pulmo marinus*" mentioned.

Some references, also relating to the sponge, which are lacking in the list of synonyms in Pallas, should now be added. In the first place a reference which is to be found in Bonanni, in his "Musæum Kircherianum" dating from 1709 and reads: "*Aliud Alcionum ex Mari Adriatico acceptum visitur, quod Tuberosum vocavit Imperatus.*" Further the "*Alcionio minore in figura di fico frutto*" mentioned and figured by Ginanni (1757) in his "Opere postume," v. 1 p. 41 t. 47 f. 98. Finally the "*Alcyonium tuberosum Ficus forma Imp.*" mentioned by Battarra in a new edition of the "Museum Kircherianum" dated 1773, p. 179 (note).

The next author after Pallas is Linnæus. In the 12th and also in the 13th Edition of the "Systema Naturæ" he records an *Alcyonium* (*Alcionium*) *Ficus* with the same synonymy as Pallas. This literature reference is thus also a partial synonym of both species.

The Dutch translation of Pallas' Elench. Zooph. by Boddært (1768), Houttuyn's edition (1772) of Linnæus' Syst. Nat. ed. 12, St. Müller's German edition (1775) of the same work, and an extract from Müller's edition by Höslin (1782) give nothing new.

The *Alcyonium Ficus*, which Berkenhout mentions in the "Outlines of the natural History of Great Britain and Ireland" dated 1769, refers to Ellis' form, and is therefore exclusively a synonym of the Ascidian. The species appears again later in both editions of the "Synopsis of the natural History of Great Britain and Ireland" by the same author dated 1789 and 1795, which constitute the 2nd and 3rd editions of the "Outlines."

To Ellis and Solander belongs the credit of having pointed out for the first time in their "History of Zoophytes," in the year 1786, the specific difference between the sponge and the ascidian. The ascidian originally called "Sea-Fig" by Ellis received the name "*Alcyonium Pulmonaria*," without however the authors having recognised its ascidian nature. For the determination of the correct specific name this reference is however of decisive significance, for here the *Alcyonium ficus* was for the first time divided into two species, of which the one (the ascidian) received the new specific name "*pulmonaria*," whilst the other (the sponge) retained the original specific name "*ficus*." Ellis and Solander refer to the mistaken union of the two species in the following words :—"This name of Sea-Fig [of Ellis] has occasioned a mistake in some late authors, who have confounded it with the Sea-Fig of Count Marsigli, which is a true sponge."

The following years yield a series of literature references, which either cannot be accurately determined or in which both species are again confounded. To the latter class belong the *Alcyonium Ficus* in the translation of Pallas' Elench. Zooph. by Wilkens and Herbst (1787), the *Alcyonium Ficus* which Meuschen records in the "Museum Geversianum" (1789), the *Alcyonium ficus* of Bruguière in the "Encyclopédie méthodique" (1787), the *Alcyonium Ficus* in Gmelin's edition of the "Systema naturæ" (1791) and in the English edition of this work by Turton (1806).

Not decisively to be indicated are the *Alcyonium Ficus*, which Olivi (1792) recorded from the Gulf of Venice, and the *Alcyonium ficus*, which Cuvier (1798) mentions in his "Tableau élémentaire" without literature reference or locality. The first of these cannot, owing to the locality where it was found, be referred to the ascidian. Whether both references belong to the sponge must remain undetermined.

To the sponge must be assigned the *Alcyonium Ficus*, which Poiret records in his "Voyage en Barbarie" of the year 1789. To the ascidian on the other hand the *Alcyonium ficus* of Bosc mentioned in his "Histoire naturelle des Vers" (1802). In the second edition of that work of the year 1827 Bosc has however again combined the two species, since he here, in addition to the reference to Ellis, gives also as a synonym the *A. Ficus* of Lamouroux (1816), which refers to the sponge.

The *Alcyonium ficus*, which Borowski and Herbst figure in their "Naturgeschichte des Thierreichs" (1787) is a copy of Ellis' figure. In the text however no literature is referred to and the locality is given as the Mediterranean. In the synonymy of the ascidian therefore only the reference to the figure can be accepted.

Esper then again separated the two species in his large work on the "Pflanzenthiere." What he describes as *Alcyonium Ficus* is the sponge, whilst the ascidian is left without a binomial designation. In Esper there is also to be found a careful summary of the literature.

In his "British Fauna" of the year 1807 Turton records an *Alcyonium Ficas* [sic !], which must be ranked as the ascidian.

Then in the years 1815 and 1816 there follow the important works of Lamarck and Lamouroux, which treat of both species under binomial names. Nevertheless the true nature of the two species was still not recognised, and they were both left in the genus *Alcyonium*. For the sponge Lamarck introduced the new but superfluous name *Alcyonium ficiforme*. The Mediterranean was given as locality. For the ascidian on the other hand the name *Alcyonium pulmonaria*, originating from Ellis and Solander, was applied, and as localities the Atlantic Ocean and the Channel were given.

Lamouroux in his "Histoire des Polypiers coralligènes flexibles," dated 1816, also retains for the ascidian the name *Alcyonium Pulmonaria*, whilst for the sponge he uses the correct nomenclature, that is to say the specific name *Alcyonium Ficus*.

By the important work of Savigny of the year 1816, it was conclusively proved that the colony-building Ascidians, which until then had been placed with the alcyonians and polyps, ought to be united to the simple ascidians. Thus Ellis' form took its place definitely amongst the ascidians, and Savigny indeed placed it in the new genus *Aplidium*, which he then founded. He only made a mistake in the choice of the specific name, since he called the species *Aplidium ficus*, instead of employing the name *pulmonaria* given to it by Ellis and

Solander. The consequence of this mistake is that the specific name *ficus* has been retained until the present day in the ascidian literature, but has also been used at the same time by writers on sponges. I have already shown that the name *ficus* cannot be maintained for an ascidian, but must fall to the sponge. Savigny does not discuss the sponge further.

Another new name for the ascidian was introduced in the same year by Lamarck in his "Histoire naturelle des Animaux sans Vertèbres." Although he recognises the genus *Aplidium* founded by Savigny, he calls the species *Aplidium sublobatum.* Why he should introduce this new specific name, although he had in the year 1815 designated the species *Alcyonium pulmonaria*, is not very easy to see. Moreover he retains the sponge in the genus *Alcyonium* and keeps the name *A. ficiforme.*

The year 1816 therefore fixes the time from whence onwards the two species finally remain separate. Ellis' form is recognised as ascidian, whilst it is not until many years later that *Alcyonium ficus* is regarded as a sponge and placed first in the genus *Suberites*, later in *Halichondria*, finally in the genus *Ficulina*, which was established specially for this species. With this definite separation of the two species only the further history of the ascidian will continue to interest us here, but before proceeding, I should like to consider briefly Lendenfeld's paper on the "Clavulina der Adria" published in 1896. A summary of the literature on *Ficulina ficus* is given in this paper, which contains some errors in the old references previous to the year 1816, which may be here corrected. In the first place there is placed amongst the synonyms the *Alcyonium pulmonis instar lobatum* of Ellis. I can only suppose that Lendenfeld had no personal acquaintance with Ellis' work, or he would never have regarded the figure which Ellis gives as that of a sponge. As the earliest literature reference Bauhin and Cherler, 1651 (not 1650!) are quoted. This is not correct. Bauhin and Cherler indeed are based on Imperato and even give an extract from the work of the latter. I have already referred to the reference to Ray (1690), which also contains an error. A further mistake, finally, is that Lendenfeld ascribes the authorship of the name *ficus* to Linnæus instead of to Pallas.

I now proceed with the history of the ascidian. After Savigny's species had been placed, in the year 1816, in his genus *Aplidium*, as *Aplidium ficus*, the specific name *ficus* was prevalent for 30 years. Only in quite isolated instances the synonymous specific name *sublobatum*, derived from Lamarck, appeared along with it. On the other hand the generic name was changed repeatedly. This is explained by the fact that Savigny's genera were to a large extent again united by later authors. Thus our species appears sometimes as *Polyclinum ficus*, sometimes as *Synoicum ficus*, sometimes as *Pulmonellum ficus*, in isolated instances indeed still as *Alcyonium ficus*. It would take us too far to discuss this literature in detail. I must content myself with pointing out here only the most important facts in the history of the species. It will be best first of all to follow, up to recent times, the specific name *ficus*, which predominated in the older literature till about the year 1850.

The older works belonging to the first half of the last century, in which the species is referred to, are without exception in the nature of compilations, and bring nothing new to our knowledge of the species. To this category belong the references by Cuvier (1817), Goldfuss (1820), Fleming (1820, 22), Schinz (1822), Fleming (1824), Lamouroux (1824), Blainville (1824, 25, 27), Fleming (1828), Stark (1828), Rang (1829), Blainville (1829, 30), Cuvier (1830), Voigt (1834), Blainville (1834), Oken (1835), Cuvier (1836), Blainville (1837), Fleming (1837), Dujardin (1837, 40), Gervais (1840), Comte (1840) (under the name *Distoma variolatus* this author gives a copy of Ellis' figure), Reichenbach (1842), Deshayes (1842), Poeppig (1848), Forbes and Hanley (1848) also do not know the species from their own observation, but quote from Ellis. From the second half of last century the following references, belonging to the same category should be mentioned: Wright (1855), Gosse (1856), H. and A. Adams (1858), M'Andrew (1861), Granger (1886), Herdman (1891), Lameere (1895), Maitland (1897), and finally also Hartmeyer (1909).

The following works contain some remarks on the species, in some cases only records of new localities:—

Alder and Hancock (1848) mention an *Aplidium ficus* from Cullercoats, but leave the identification uncertain. The record of locality had better therefore for the present remain doubtful, although it is not unlikely that the species occurs there.

Cocks (1850) records in his list of the Ascidians of Falmouth an *Aplidium ficus*. The identification cannot be tested. That the species occurs on the south coast of England I consider doubtful, until the contrary is proved. At any rate I have not found it amongst the extensive collection from Plymouth which I have examined. This locality therefore may for the present remain doubtful.

Gervais and P. J. Beneden (1859) give the North Sea as a locality. P. J. Beneden (1860) records the occurrence of *Aplidium ficus* in deep water on the Belgian coast in company with a second species which he calls *Aplidium ficoides*. Details of the anatomy are not given however, but it seems possible to decide with certainty from the external characters alone that it refers to our species. *Aplidium ficoides* is probably only a synonym. I have recently had in my hands many colonies which were also collected off the Belgian coast, so that the occurrence of the species there is certain.

Ansted and Latham also record *Aplidium ficus* in a list of the Ascidians of the Channel Islands. This statement cannot be tested. I have myself not seen any example of this species from the Channel Islands, although I have identified a great deal of ascidian material from that locality. It appears however by no means improbable that the species occurs there, probably in deeper water. I come to that conclusion because Giard (1873) also mentions a *Polyclinum ficus* from the neighbouring coast of Granville, which he identifies as Ellis' species. I do not doubt that this *P. ficus* of Giard is the same as our species. Giard thinks it probable that the species lives in deep water and is only occasionally thrown on the shore. That would also explain the fact that the species is mentioned neither by Milne-Edwards nor by Lahille, and consequently we may conclude that it does not occur within the limits of the true littoral zone on the north coast of France.

Pelseneer (1892) mentions the species from Blankenberghe, where it is frequently taken by the fishermen; Bizet (1892) from the coast of Somme. It seems to me however questionable whether in the latter case our species is really concerned, possibly there is a confusion with *Glossoforum sabulosum*. Sharp (1911) mentions the species again from the Channel Islands (Cobo). The same remarks apply to this record as to that of Ansted and Latham. Finally in the posthumous work of Alder and Hancock (1912) published by Hopkinson a numerous collection of references to this species is to be found, in which however references which belong to the sponge are erroneously included. In other respects this work furnishes nothing new.

An *Aplidium* or *Polyclinum ficus* is also repeatedly recorded from the *Mediterranean*. Thus by Martens (1824), Grube (1864), Faber (1883), and Carus (1890); Targioni-Tozzetti (1880) mentions an *Aplidium sublobatum*. In all these cases there is a mistaken identification, since our species does not occur in the Mediterranean. Probably in most cases the form dealt with is *Amaroucium pyramidale* (Brug.) (Syn. *A. conicum* (Olivi)).

It is interesting to follow how in the course of years the specific name *ficus* disappears more and more from the literature. Up to the middle of the last century one misses it in hardly a single general work on ascidians. In the fifties and sixties also it is still somewhat frequently mentioned. After that the name becomes constantly less frequent and in the most recent times it has as good as completely disappeared from the literature. But although in the older literature the species was recorded so very frequently, no author has given us an anatomical description sufficient to enable us to place the species with certainty in the present system. For in order to recognise the form, as Giard does, as *Polyclinum*, the proof must first be forthcoming that it actually agrees with the genus *Polyclinum* in the arrangement of the intestinal loop, the most important generic character of that genus. For such a proof one seeks in vain in the whole literature of the species. The form has remained, one may rather say, problematical as regards its systematic position up to the present day. By the re-examination of typical, local specimens this question is now solved. The identity of the *Alcyonium pulmonis instar lobatum* of Ellis with the frequently mentioned *Macroclinum pomum* (Sars) of recent literature has been established.

The latter species was first described by Sars (1851) as *Amaroucium pomum*, and was placed later by Huitfeldt-Kaas (1896) in the genus *Aplidiopsis* founded by Lahille; together with a newly described species *A. sarsii*. Hartmeyer (1903) then recognised the near relationship of these two species to *Macroclinum crater*, described by Verrill (1871), from the Newfoundland Banks, which was the type of the new genus *Macroclinum*, *Aplidiopsis sarsii* was explained as a synonym of *M. crater*, whilst *A. pomum* was placed as an independent species in the genus *Macroclinum*. Bjerkan (1905) afterwards showed that *M. crater* and *M. pomum* were also synonyms, and that the species should bear the latter name. This name has been retained until the present day. Now the name *pomum* has to be replaced by the older name *pulmonaria*, so that the species must now be called *Macroclinum pulmonaria* (Ell. Sol.). Naturally the position of the species as type of the genus *Macroclinum* remains unaffected by this change of name.

In conclusion I add a list of the most important references to *Ficulina ficus* (Pall.) up to the year 1816, as well as of the whole literature on *Macroclinum pulmonaria* (Ell. Sol.) as far as it is known to me

FICULINA FICUS (PALL.).

1478 "*Alcionii quinta species*," Dioscorides, Materia medica, lib. 5 cap. 90.

1599 "*Alcyonio tuberoso in forma di fico, frutto: Alcyonio quinto di Dioscoride*," Imperato, Stor. nat., p. 734 f.

1651 "*Alcyonium tuberosum*," Bauhin & Cherler, Hist. Plant. univ., *v.* 3 lib. 39 p. 817 f.

1709 "*Alcionum . . ., quod Tuberosum vocavit Imperatus,*" Bonanni, Mus. Kircher., p. 267.

1717 "*Alcyonium quintum*" (*quintum antiquorum alcyonium*), Mercati, Metallotheca Vatic., p. 102 f.

1725 "*Figue de substance d'Eponge & d'Alcion, nommée par Trionfetti, Alcyonium tuberosum, forma ficus Imperati,*" Marsilli, Hist. phys. Mer, p. 87 t. 16 f. 79.

1757 "*Alcionio minore in figura di fico frutto,*" Ginanni, Oper. post., *v.* 1 p. 41 t. 47 f. 98.

1766 *Alcyonium Ficus* (part.), Pallas, Elench. Zooph., p. 356.

1767 *Alcyonium Ficus* (part.), Linné, Syst. Nat., ed. 12 *v.* 1 II p. 1295.

1767 *Alcionium Ficus* (part.), Linné, Syst. Nat., ed. 13 *v.* 1 II p. 1295.

1773 "*Alcyonium tuberosum Ficus forma Imp.,*" Battarra in: Bonanni, Mus. Kircher., p. 178, 179 nota.

1786 "*Sea-Fig,*" Ellis & Solander, Zooph., p. 206 t. 59 f. 4.

1789 *Alcyonium Ficus,* Poiret, Voy. Barbarie, *v.* 2 p. 57.

1791 *Alcyonium Ficus* (part.), Gmelin, Syst. Nat., *v.* 1 VI p. 3813.

?1792 *Alcyonium Ficus,* Olivi, Zool. Adriat., p. 240.

?1798 *Alcyonium ficus,* G. Cuvier, Tabl. élém., p. 682.

1806 *Alcyonium ficus,* Esper, Pflanzenth., pars 3 fasc. 2 (14) p. 63 t. Alc. 20 f. 1–4.

1815 *Alcyonium ficiforme,* Lamarck in: Mém. Mus. Paris, *v.* 1 p. 75.

1816 *Alcyonium ficiforme,* Lamarck, Hist. An. s. Vert., *v.* 2 p. 394.

1816 *Alcyonium Ficus,* Lamouroux, Hist. Polyp., p. 348.

1896 *Ficulina ficus,* Lendenfeld in: N. Acta Ac. Leop., *v.* 69 nr. 1 p. 94.

MACROCLINUM PULMONARIA (Ell. Sol.).

1755 *Alcyonium pulmonis instar lobatum,* Ellis, Corallin., p. 82 t. 17 f. b, B, C, D. non bin.

1756 *Alcyonium pulmonis instar lobatum,* Tak, Ellis Koraal-Gewass., p. 89 t. 17 f. b, B, C, D. non bin. [Dutch translation of Ellis, Corallin.]

1756 *Alcyonium pulmonis instar lobatum,* Allamand, Ellis, Corallin., p. 97 t. 17 f. b, B, C, D. non bin. [French translation of Ellis, Corallin.]

1766 *Alcyonium Ficus* (part.), Pallas, Elench. Zooph., p. 356.

1767 *Alcyonium Ficus* (part.), Linné, Syst. Nat., ed. 12 *v.* 1 II p. 1295.

1767 *Alcionium Ficus* (part.), Linné, Syst. Nat., ed. 13 *v.* 1 II p. 1295.

1767 *Alcyonium pulmonis instar lobatum,* Krüniz, Ellis, Corall-Art., p. 89 t. 17 f. b, B, C, D. non bin. [German translation of Ellis, Corallin.]

1768 *Alcyonium ficus* (part.), Boddært, Plant-Dier., p. 442 t. 11 f. 3. [Dutch translation of Pallas, Elench. Zooph.].

1769 *Alcyonium Ficus,* Berkenhout, Outl. Hist. Great Brit., *v.* 1. p. 210.

1772 *Alcyonium Ficus* (part.), Houttuyn, Natural. Hist., pars 1 *v.* 17 p. 398. [Dutch translation of Linné, Syst. Nat., ed. 12.]

1775 *Alcyonium ficus* (part.), St. Müller, Natursyst. Linné, *v.* 6 II p. 787. [German translation of Linné, Syst. Nat., ed. 12.]

1782 *Alcyonium ficus* (part.), Höslin, Linné, Natur-Syst., *v.* 2 p. 608.

1786 *Alcyonium Pulmonaria*, Ellis & Solander, Zooph., p. 175.
1787 *Alcyonium Ficus* (part.), Meuschen, Mus. Gevers., p. 532.
1787 *Alcyonium Ficus* (part.), Wilkens & J. F. W. Herbst, Pallas Thierpfl., *v.* 2 p. 121 t. 18 f. 63. [German translation of Pallas, Elench. Zooph.]
1787 *Alcyonium ficus*, J. F. W. Herbst in: Borowski & J. F. W. Herbst, Naturg. Thierr., atl. *v.* 9 t. 65 f. 1 a, b.
(non 1787 *Alcyonium ficus*, J. F. W. Herbst in: Borowski & J. F. W. Herbst, Naturg. Thierr., *v.* 10 p. 77.)
1789 *Alcyonium Ficus*, Berkenhout, Synops. Hist. Great Brit., ed. 2 *v.* 1 p. 213.
1789 *Alcyonium ficus* (part.), Bruguière in: Enc. méth., Vers *v.* 1 p. 26.
1791 *Alcyonium Ficus* (part.), Gmelin, Syst. Nat., *v.* 1 VI p. 3813.
1795 *Alcyonium Ficus*, Berkenhout, Synops. Hist. Great Brit., ed. 3 *v.* 1 p. 213.
1802 *Alcyonium ficus*, Bosc, Hist. Vers, *v.* 3 p. 133.
1806 *Alcyonium Ficus* (part.), Turton, Syst. Nat. Gmelin, *v.* 4 p. 653. [English edition of Gmelin, Syst. Nat.]
1806 *Alcyonium Ficus* (part.), Esper, Pflanzenth., *v.* 3 fasc. 2 (14) t. Alc. 20 f. 5–8.
1807 *Alcyonium Ficas* (err.), Turton, Brit. Fauna, *v.* 1 p. 207.
1815 *Alcyonium pulmonaria*, Lamarck in: Mém. Mus. Paris, *v.* 1 p. 76.
1816 *Alcyonium Pulmonaria*, Lamouroux, Hist. Polyp., p. 342.
1816 *Aplidium sublobatum*, Lamarck, Hist. An. s. Vert., *v.* 3 p. 95.
1816 *Aplidium ficus*, Savigny, Mém. An. s. Vert., *v.* 2 p. 183.
1817 *Polyclinum ficus*, G. Cuvier, Règne an., *v.* 2 p. 501.
1817 *Alcyonium ficus*, Anonym in: Enc. Brit., ed. 5 *v.* 10 p. 358.
1820 *Polyclinum ficus*, Goldfuss, Handb. Zool., *v.* 1 p. 591.
1820 *Alpidium* (err.) *ficus*, J. Fleming in: Edinb. Enc., *v.* 14 p. 631.
1821 *Aplidium ficus*, Lamouroux, Expos. Polyp., p. 74.
1822 *Aplidium* (err.) *ficus*, J. Fleming, Phil. Zool., *v.* 2 p. 514.
1822 *Polyclinum Ficus*, Schinz, Thierr. Cuvier, *v.* 2 p. 781.
1824 *Aplidium ficus*, Lamouroux in: Enc. méth., Zooph. p. 75.
1824 *Synoicum Ficus*, Blainville in: Dict. Sci. nat., *v.* 32 p. 367.
1824 *Alpidium* (err.) *ficus*, J. Fleming in: Enc. Brit., ed. 4, 5, 6 suppl. *v.* 5 p. 583.
(non 1824 *Polyclinum ficus*, G. Martens, Reise Venedig, *v.* 2 p. 480.)
1825 *Synoicum Ficus*, Blainville, Man. Malac., p. 587 t. 82 f. 6, 6 a, 6 b.
1827 *Synoicum ficus*, Blainville in: Dict. Sci. nat., *v.* 51 p. 484.
1827 *Alcyonium ficus* (part.), Bosc, Hist. Vers, ed. 2 *v.* 3 p. 160.
1828 *Alpidium* (err.) *ficus*, J. Fleming, Hist. Brit. An., p. 470.
1828 *Aplidium sublobatum*, Stark, El. nat. Hist., *v.* 2 p. 121.
1829 *Synoicum ficus*, Rang, Man. Moll., p. 355.
1830 *Pulmonellum ficus*, Blainville in: Dict. Sci. nat., *v.* 60 p. 489.
[1816–1830] "*Synoique sublobé*" [*Synoicum ficus*], Blainville in: Dict. Sci. nat., pl. Zool. Conchyl. t. 113 f. 6, 6 a.
1830 *Polyclinum ficus*, G. Cuvier, Règne an., ed. 2 *v.* 3 p. 169.

1834 *Polyclinum Ficus*, F. S. Voigt, Thierr. Cuvier, *v.* 3 p. 596.
1834 *Pulmonellum ficus*, Blainville, Man. Actin., p. 526.
1835 *Alcyonium ficus*, Oken, Allg. Naturg., *v.* 5 I p. 93.
1836 *Polyclinum ficus*, G. Cuvier, Règne an., ed. 3 *v.* 2 p. 105.
[1837] *Pulmonella ficus*, Blainville, Man. Actin., p. 683.
1837 *Alpidium* (err.) *ficus*, J. Fleming in: Enc. Brit., ed. 7 *v.* 15 p. 370; Moll. An., p. 213.
1837 *Aplidium sublobatum*, Dujardin in: Lamarck, Hist. An. s. Vert., ed. 3 *v.* 1 p. 570.
1840 *Aplidium sublobatum*, Dujardin in: Lamarck, Hist. An. s. Vert., ed. 2 *v.* 3 p. 489.
1840 *Aplydium* (err.) *ficus*, Gervais in: Dict. Sci. nat., suppl. *v.* 1 p. 410.
[1840] *Distoma Variolatus* (part.) + *Synoicum Ficus*, Comte, Règne an., t. 28 f.
1842 *Polyclinum Ficus*, Reichenbach, Conchil., p. 125.
[1842] *Polyclinum ficus*, Deshayes in: Cuvier, Règne an. [ed. 4], Moll. p. 245.
1848 *Aplydium* (err.) *ficus*, Poeppig, Naturg. Thierr, *v.* 4 p. 223 f. 3945 a, b.
1848 *Aplidium ficus*, Alder & Hancock in: Tr. Tyneside Club, *v.* 1 p. 203.
1848 *Aplidium ficus*, E. Forbes in: E. Forbes & Hanley, Brit. Moll., *v.* 1 p. 11.
?1850 *Aplidium ficus*, Cocks in: Rep. Cornwall Soc., 1849 p. 73.
1851 *Amaroucium pomum*, M. Sars in: Nyt. Mag. Naturv., *v.* 6 p. 155.
1855 *Aplidium ficus*, Wright in: Nat. Hist. Rev., *v.* 2 Proc. p. 70.
1856 *Aplidium ficus*, Gosse, Man. mar. Zool., *v.* 2 p. 32.
1858 *Aplidium ficus* + *Amouroucium pomum*, H. & A. Adams, Gen. Moll. p. 600, 601.
1859 *Amaroucium pomum*, M. Sars in: Forh. Selsk. Christian., 1858 p. 66.
1859 *Aplydium* (err.) *ficus*, Gervais & P. J. Beneden, Zool. méd., *v.* 2, p. 74.
1860 *Aplidium ficus*, P. J. Beneden in: Bull. Ac. Belgique, ser. 2 *v.* 9 p. 154.
1861 *Aplidium ficus*, McAndrew in: Rep. Brit. Ass., *v.* 30 p. 222.
?1862 *Aplidium ficus*, Ansted & Latham, Chann. Isl., p. 219.
1863 *Amaroecium* (err.) *pomum*, Alder in: Ann. nat. Hist., ser. 3 *v.* 11 p. 170.
(non 1864 *Aplidium ficus*, Grube, Lussin, p. 58.)
1865 *Polyclinum* sp., Alder in: Nat. Hist. Tr. Northumb., *v.* 1 p. 11.
1871 *Macroclinum crater*, A. E. Verrill in: Amer. J. Sci., ser. 3 *v.* 1 p. 293 f. 23–25.
1872 *Macroclinum crater*, A. E. Verrill in: Amer. J. Sci., ser. 3 *v.* 3 p. 212.
1873 *Polyclinum ficus*, Giard in: Arch. Zool. expér., *v.* 2 p. 493.
1879 *Macroclinum crater*, A. E. Verrill, Check. L. mar. Invert., p. 27.
(non 1880 *Aplidium sublobatum*, Targioni-Tozzetti, Espos. Pesca Berlino, cat. ital. p. 137.)

1882 *Aplydium* (err.) *ficus*, Pelseneer in: Ann. Soc. malac. Belgique, *v.* 17 p. 40.
(non 1883 *Polyclinum ficus*, G. L. Faber, Fish. Adriatic, p. 251.)
1886 *Aplidium ficus*, Granger in: Hist. nat. France, *v.* 7 p. 206.
(non 1890 *Aplidium ficus*, J. V. Carus, Prodr. F. Medit., *v.* 2 p. 483.)
1891 *Polyclinum ficus*, Herdman in: J. Linn. Soc. London, *v.* 23 p. 619.
1891 *Amaroucium pomum*, Herdman in: J. Linn. Soc. London, *v.* 23 p. 628.
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1895 *Polyclinum ficus*, Lameere, Man. Faune Belgique, p. 42 f. 5.
1896 *Aplidiopsis pomum*, Huitfeldt-Kaas in: Norske Nordhavs-Exp., *v.* 7 ser. 23 I p. 13 t. 1 f. 8–10.
1896 *Aplidiopsis sarsii*, Huitfeldt-Kaas in: Norske Nordhavs-Exp., *v.* 7 ser. 23 I p. 14 t. 1 f. 11–13.
1897 *Amaroucium pomum*, Norman, Mus. Norman., cat. IX p. 6.
1897 *Aplidium ficus*, Maitland, Prodr. Faune Pays-Bas, p. 34.
1903 *Macroclinum crater*, Hartmeyer in: Fauna arctica, *v.* 3 p. 319 t. 6 f. 5; t. 13 f. 6, 7.
1903 *Macroclinum pomum*, Hartmeyer in: Faune arctica, *v.* 3 p. 322.
1905 *Macroclinum pomum*, Bjerkan in: Bergens Mus. Aarbog, 1905 nr. 5 p. 17.
1906 *Macroclinum pomum*, Hartmeyer in: Wiss. Meeresunters, *v.* 8 p. 126.
1907 *Macroclinum crater*, Redikorzew in: Annuaire Mus. St.-Pétersb., *v.* 11 p. 148, 153.
1908 *Macroclinum pomum*, Bjerkan in: Tromsö Mus. Aarsh., nr. 25 p. 88.
1909 *Polyclinum ficus*, Hartmeyer in: Bronn's Kl. Ordn., *v.* 3 suppl. p. 1461, 1481.
1909 *Macroclinum pomum*, Hartmeyer in: Bronn's Kl. Ordn., *v.* 3 suppl. p. 1464.
1909 *Aplidium sublobatum*, Hartmeyer in: Bronn's Kl. Ordn., *v.* 3 suppl. p. 1469.
1910 *Macroclinum pomum*, Hartmeyer in: Bronn's Kl. Ordn., *v.* 3 suppl. p. 1584 nota.
1910 *Macroclinum pomum*, Van Name in: P. Boston Soc., *v.* 34 p. 396 f. 21 t. 38 f. 8.
1910 *Macroclinum pomum*, Redikorzew in: Trav. Soc. St.-Pétersb., *v.* 41 fasc. 2 p. 156 f. 42.
1911 *Macroclinum pomum*, Redikorzew & Hartmeyer in: Derjugin in: Trav. Soc. St.-Pétersb., *v.* 42 fasc. 1 nr. 1–2 p. 24.
1911 *Polyclinum ficus*, W. E. Sharp in: Rep. Guernsey Soc., 1910 p. 207.
1912 *Amaroucium pomum*, Alder & Hancock, Brit. Tun., *v.* 3 p. 16.
1912 *Aplidium ficus*, Alder & Hancock, Brit. Tun., *v.* 3 p. 23, 101 f. 97–99.
1912 *Macroclinum pomum*, Hartmeyer in: Vid. Meddel., *v.* 63 p. 280.

DISTRIBUTION.

England and Scotland: Moray Firth (Alder 1863)—? Cullercoats (Alder and Hancock 1848)—West Mersea—Sheerness (Berkenhout 1769)—Whitstable (Ellis 1755)—? Falmouth (Bream Bay; Helford River) (Cocks 1850).

English Channel: (Lamarck 1815)—(Granger 1886).

Channel Islands: Guernsey (Ansted and Latham 1862)—Cobo (Sharp 1911).

North Coast of France: Granville (Giard 1873)—Somme (Bizet 1892).

Belgian Coast: (Beneden 1860)—Blankenberghe (Pelseneer 1882).

North Sea: (Gervais and Beneden 1859)—Heligoland (Hartmeyer 1906)—Dogger Bank (Alder 1865; Hartmeyer 1906)—Great Fisher Bank (Hartmeyer 1906)—56° 1′ N. 4° 49′ E., 38 m.—S.W. Lindesnaes, 57° 2′ N. 4° 3′ E., 64 m.—57° 11′ N. 0° 11′ E., 78 m.—57° 41′ N. 5° 35′ E., 100 m.—57° 20′ N. 8° 2′ E., 57 m. (Bjerkan 1905). *

Scandinavia and Denmark: Baadsfjord (E.-Finmark), 65 m. (Bjerkan 1905)—Gjesver (Bjerkan 1908)—Havösund, 72 m. (Sars 1851)—Tromsö, 54–72 m. (Hartmeyer 1903)—Tromsösund, 40–100 m. (Bjerkan 1908)—Ure, Lofoten, 36 m. (Sars 1851)—Vestfjord near Bodö, 105–160 m.—Trondhjemsfjord: Skarnsund, 150–200 m.; off Tautra, ca. 200 m.; off Rödberg, ca. 300 m. (Hartmeyer 1912); Rödberg (Herdman 1893)—Hessefjord, near Aalesund, 90 m. (Bjerkan 1905)—Bohuslän—Beian—Christiansund (Huitfeldt-Kaas 1896)—Hellebaek (Mus. Berlin) *—Grosser Belt (Mus. Berlin). †

Murman Coast: Kola Fjord (Redikorzew and Hartmeyer 1911).

Spitzbergen: Stor Fjord, 77° 8′ N. 20° E., 155 m. (Redikorzew 1907).

Faröe Islands: North point of Nolsö, ca. 180 m. (Hartmeyer 1912)—East of Faröes, 62° 16′ N. 6° 6′ W., 110 m. (Bjerkan 1905).

Iceland: S.E. coast of Iceland, 64° 17′ N. 14° 44′ W., 75 m. (Bjerkan 1905).

Greenland: S. of Cape Farewell (Hartmeyer 1910).

North East America: Newfoundland (Verrill 1871; Hartmeyer 1903; Van Name 1912)—Virgin Rock, 72 m. (Van Name 1912).

Macroclinum pulmonaria is a decided sub-arctic species, which is distributed right across the North Atlantic from the east coast of North America to the Murman coast. On the American side it has only been found in Newfoundland. In the eastern part of the North Atlantic its most southerly locality is the north coast of France (Granville) and the Channel. It has not yet however certainly been proved to occur on the south coast of England, nor has it been found in the Irish Sea, on the Irish coasts, nor on the west coast of Scotland. On the other hand it is known from various points on the east coasts of

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* Also collected at many other places in the North Sea during the quarterly cruises of the *Poseidon* and of the Heligoland fishery research vessels during the years 1902–5.

† The Berlin Museum possesses in each case one small colony of this species from Hellebaek, Gundel leg., and from the Greater Belt, collected during the *Pommerania* expedition. Both localities are new.

Scotland and England. From the Channel it extends along the Belgian coast and through the whole North Sea, where it appears to be very abundant everywhere, enters Danish waters (Greater Belt), and then follows the whole west coast of Sandinavia by Lofoten and Finmark to the Murman coast. Here its most easterly locality is the Kola Fjord. Towards the north it spreads through the Faröe Islands and Iceland to the neighbourhood of Cape Farewell on the one side and the Stor Fjord (Spitzbergen) on the other. Only at these two points does it go within the Arctic Circle, and it seems always to remain in the neighbourhood of the warmer currents. The whole area of distribution extends therefore from west to east from 48° W. to 34° E., from south to north from 48° 50′ N. to 77° 8′ N., or through 82 degrees of longitude and 29 degrees of latitude.

The species generally prefers deeper water. The vertical distribution lies, as far as the records show, between 38 and 300 metres. A decided littoral form the species is certainly not. In the Channel it appears to occur only in deeper water, and is absent from the coastal zone. In many places it is clearly extraordinarily abundant, as for example in the North Sea, especially in the neighbourhood of the Dogger Bank and the Great Fisher Bank. The species appears to live chiefly on sandy ground.

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On Ciliary Mechanisms in Brachiopods and some Polychætes, with a Comparison of the Ciliary Mechanisms on the Gills of Molluscs, Protochordata, Brachiopods, and Cryptocephalous Polychætes, and an Account of the Endostyle of Crepidula and its Allies.

By

J. H. Orton, B.Sc., A.R.C.Sc.

With twelve Figures in the Text.

TABLE OF CONTENTS.

PAGE
Introduction 283
Ciliary mechanisms producing the main food and respiratory current in Brachiopods 284
Ciliary mechanisms on the gill-filaments and lophophore 287
The ciliation of the gill-filaments of Brachiopods 293
Summary of current-producing mechanisms and the mode of feeding in Brachiopods 294
An explanation of some morphological characters in fossil and recent Brachiopods 295
Comparison of the ciliary mechanisms on the gills of Gastropods, Lamellibranchs, Amphioxus, and Brachiopods 297
The ciliary mechanisms on the gills of Cryptocephalous Polychætes and on the lophophore of Phoronis 301
The endostyle of Crepidula and Calyptræa 303
Comparison of the adaptations in Brachiopods and Lamellibranchs to the process of feeding 307
Summary 308

INTRODUCTION.

The results of the writer's investigations on the ciliary mechanisms on the gills of Mollusca and Amphioxus (1 and 2) gave rise to the suggestion that similar mechanisms might probably also occur in Brachiopods, for it is a well-known fact that Brachiopods—like some Molluscs and Amphioxus—feed on the smaller organisms which are to be found floating in the sea. Owing to the kindness of Dr. H. C. Williamson, of Aberdeen, I have been able to examine living Crania which were obtained by dredging in Loch Fyne, and living Terebratula have also been obtained from Naples. An investigation of the living gill-filaments—or lophophoral cirri, as they are frequently termed in this group—showed that the ciliary mechanisms on these filaments are essentially the same as those occurring on the gill-filaments of Amphioxus, Lamellibranchs, some Gastropods, and most Ascidians. As it was found that existing accounts of the mode of feeding in Brachiopods are vague and incomplete the following description of the process has been written.

The nutritive currents in Brachiopods were the subject of an investigation by J. Hérouard (3) as early as 1877. This writer conceived the ingenious plan of investigating these currents by constructing artificial lophophores of lead piping perforated in places corresponding to the point of attachment of the filaments. It was assumed that a representation of the action of the tentacles would be obtained by squirting water under pressure through the holes in the artificial lophophore. Unfortunately, examination of the living filaments shows at once that this assumption is wrong, and that the experiments consequently were valueless. The gills of Brachiopods have, however, been investigated more recently by Shipley, who described the gill-filaments of Argiope as having cilia on three of their four sides, and figures these cilia as being all similar (see 4, Plate 39, Fig. 13). Later, Shipley (5) states that in Brachiopods " the cilia which clothe the tentacles (i.e. gill-filaments or cirri) keep up a constant flow of water into the mantle cavity. This stream not only serves to aerate the blood of the animals—a process which probably takes place through the thin inner lining of the mantle —but it also brings with it a number of diatoms and other minute organisms which serve as food. These particles become entangled in the tentacles, and are ultimately lodged in the groove at their base, and passing along this by the action of the cilia they find their way into the wide mouth, into which the groove deepens in the posterior median line." It will thus be seen that the manner in which the chief food-current is produced and the differentiation of gill-cilia noted in the following pages have not been described. Moreover, it will be shown here that there exist in various parts of the body other ciliary mechanisms than those on the gill, which play an important part in the process of feeding.

CILIARY MECHANISMS PRODUCING THE MAIN FOOD AND RESPIRATORY CURRENT IN BRACHIOPODS.

Brachiopods—like Amphioxus, some Molluscs, and other animals—obtain their food by maintaining a continuous current of water through a cavity enclosed by portions of the body, and capturing the organisms brought along with the current by means of a suitable organ, namely the lophophore, placed between the ingoing and the outgoing currents.

The main food and respiratory stream in Crania enters the mantle cavity at *both* sides and is expelled in the middle of the front of the shell opposite the hinge (see Fig. 1). It will be remembered that the lophophore in Brachiopods is distributed symmetrically on each side of the antero-frontal axis of the shell. The effect of this disposition is—as will be shown later—to divide the mantle cavity in a physiological sense* into two compartments, each containing a half of the lophophore on each side of the mouth. Consequently two inhalent streams are necessary and enter the mantle cavity, as shown in Figs. 1 and 2. The exhalent streams are, however, combined in Crania, Lingula, and probably most recent Brachiopods in the middle line in the front region of the shell.

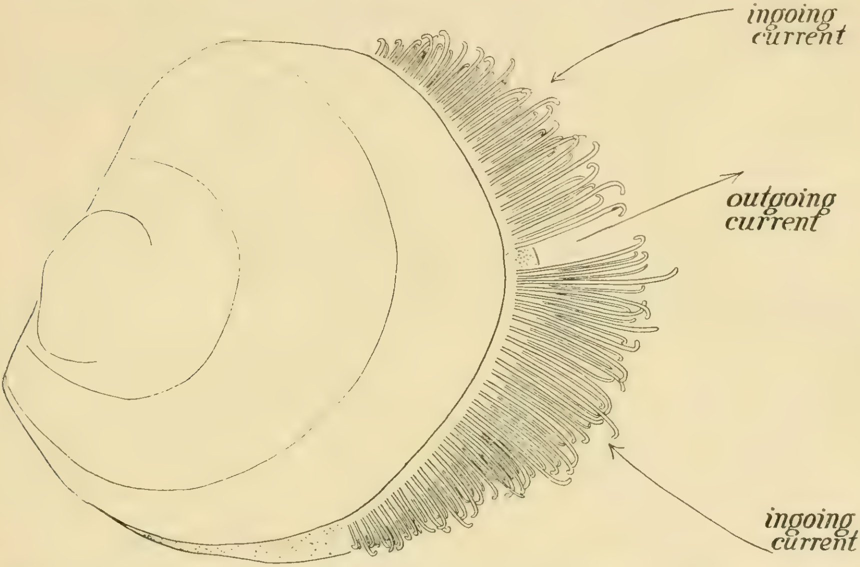

Fig. 1.—View of Crania attached to a stone in the act of feeding. Drawn from the living animal and chiefly from the right side (× 10). An ingoing current is drawn into the lower portion of the mantle cavity on each side in the antero-lateral region. The outgoing current leaves the region of the shell in the front middle line. The double row of the protruded gill-filaments is well shown.

These main food-currents in Brachiopods are produced chiefly by the lashings of definite rows of cilia situated along the sides of the filaments of the lophophore (see Figs. 3 and 7, pp. 287, 292). Groups of other cilia, however, on other parts of the lophophore and on the mantle assist in producing these food-streams. The action of the mantle cilia indicates fairly well the course of the food and respiratory streams through the mantle cavity, and the directions in which the cilia on the lower mantle lash are indicated by the arrows in Fig. 2. From the figure it will be seen that the cilia lash from both lateral regions of the shell towards the front middle region. Besides assisting in producing the main current these cilia also reject from the mantle cavity the heavier undesirable particles brought into the shell in the main stream. On the mantle lining the upper valve the cilia lash on the whole in similar directions to those on the lower one; there are, however, these differences, the cilia on either side of those in the front middle region lash more and more away from the middle the nearer they are situated to the anterior edge of the mantle. Thus two vortices tend to be formed in the right and left upper portions of the mantle cavity. On the dorsal mantle cilia also lash from between the anterior and posterior occlusor muscles on each side towards the posterior sinus of the mantle cavity which constitutes the space bounded by the posterior

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* The mantle cavity is in many genera partially divided also morphologically by septa, viz. Waldheimia, Stringocephalus. (See also p. 295.)

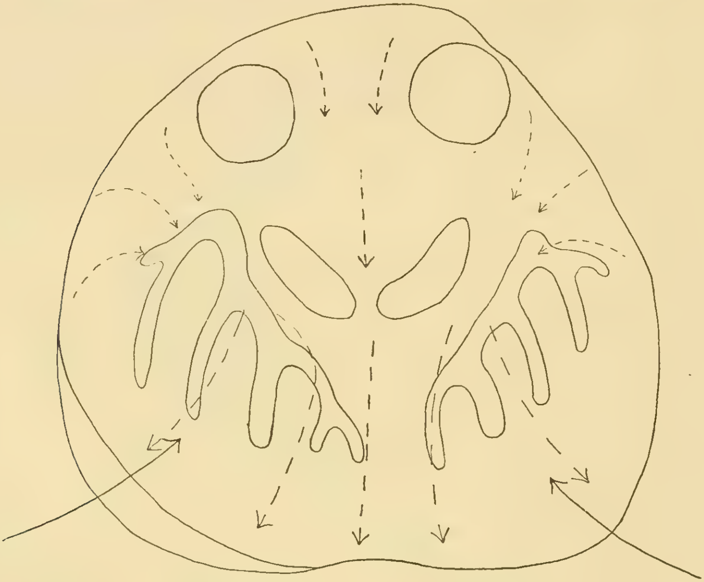

FIG. 2.—View of the ventral valve of Crania, showing the ciliary currents on the mantle (× rather more than 3).

This view serves almost equally well for the ciliary currents on the dorsal mantle.

The dotted arrows indicate the direction in which the mantle cilia lash, and the large continuous arrows the regions where the greatest volume of the ingoing current enters the mantle cavity.

occlusors and the "hinge." Into this sinus opens the anus. An outgoing current from this part of the mantle cavity passes between the anterior occlusors to join the main outgoing stream (see Fig. 2). Thus the currents set up by the mantle cilia on each side of the mantle cavity divide into two streams, the major one passing towards the middle of the cavity and out at the front of the shell in the middle line, and a minor one passing between the occlusor muscles into the posterior sinus, from which the outgoing stream passes between the anterior occlusors to join the major outgoing stream. It will be shown later that the currents set up by the mantle cilia are in the main coincident with those produced by the current-producing cilia on the gill-filaments and certain cilia on the lophophore.

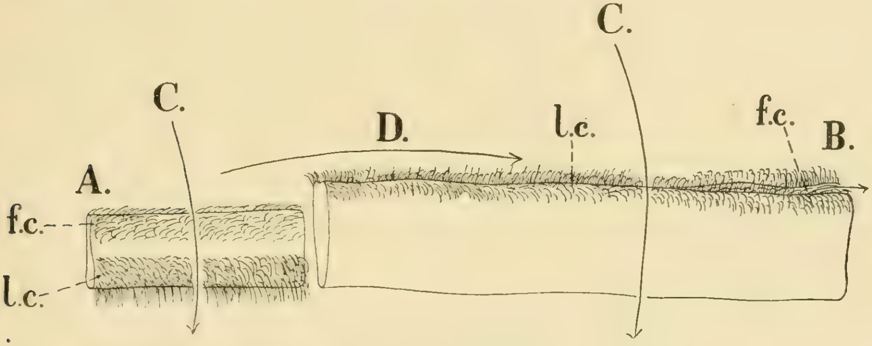

FIG. 3.—Lateral views of living gill-filaments of Crania (× about 56).

A.	*View of portion of a filament of the ventral series (the letter is placed near the distal end of the filament segment).
B.	View of portion of a filament of the dorsal series (the letter is placed near the proximal end of the filament segment).
C.	Arrow indicating the direction in which the lateral cilia, l.c., lash.
l.c.	Lateral cilia which produce the main current.
D.	Arrow indicating the direction in which the frontal cilia, f.c., lash.
f.c.	Frontal cilia which collect and transport food-particles.

CILIARY MECHANISMS ON THE GILL-FILAMENTS AND LOPHOPHORE.

The examination of living gill-filaments of Crania and Terebratula under a high power of a microscope revealed the presence of two sets of cilia† which correspond in function and position to those on the filaments of Amphioxus, many Molluscs, and most Ascidians. These sets of cilia are well shown in the transverse sections of the filaments

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* This view would serve equally well for the tips of both kinds of filaments.

† Blochmann (10) has already figured the differentiation of cilia on the filaments of Crania, without, however, making any observations on their function.

shown in Fig. 7, p. 292, and in the lateral view of a living filament shown in Fig. 3. From these figures it is seen that the cilia are differentiated into three rows, one extending along that face of the filament which faces the incoming current, and two extending either along the sides of the filaments or along the edges of the filaments at the sides of the former row. Those rows of cilia on the face of the filament facing the incoming current may be called frontal cilia in comparison with the similar cilia described in Molluscs and Amphioxus (see 1 and 2), while the rows of cilia on the sides of the filaments may be similarly called lateral cilia. Thus the faces of the filaments may be termed respectively frontal, lateral, and ab-frontal, the latter being the face opposite the frontal. The lateral cilia (well shown in Figs. 3 and 7 l.c.) are the chief producers of the main food and respiratory current in Brachiopods. They lash across the length of the filament, as shown in Fig. 3, from the lower portion of the mantle cavity to the upper. The origin of the lophophore

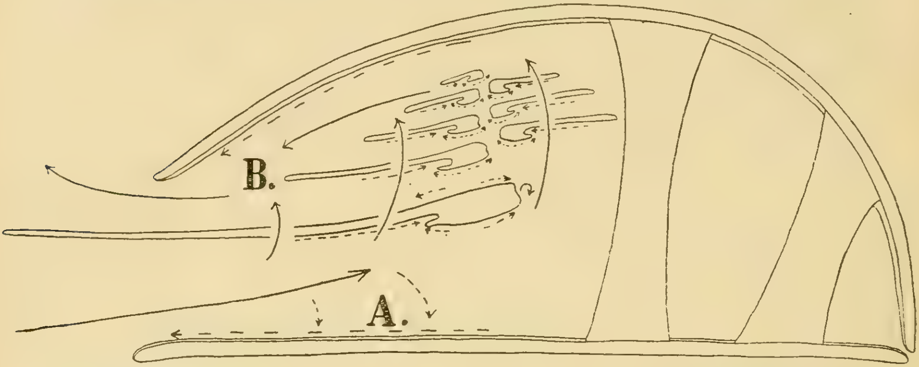

FIG. 4.—Diagram of the currents present in the mantle cavity of a Brachiopod as represented by Crania.

The diagram represents a section taken on one side of the median antero-posterior axis through the shell and the whorls of the lophophore. One anterior and one posterior occlusor muscle are shown.

The larger arrows indicate the course of the main current through the mantle cavity. The large arrow whose head ends above the letter A indicates the course of the ingoing current and the one beginning below B that of the outgoing current. The three arrows between and to the right of A and B indicate the course of the current through the gill-filaments on the lophophore. The dotted arrows on either side of A indicate the region where the heavier food-particles fall out of the main stream on to the mantle and are expelled by the mantle cilia as indicated by the long dotted arrow placed parallel to the lower mantle. The direction in which the cilia lash on the dorsal mantle is shown by the dotted arrow alongside it. The small dotted arrows on the lophophore and gill-filaments show the course of the food-collecting streams.

A. Inhalent chamber of one side.

B. Exhalent chamber of one side.

from the body is such that the plane of the first and longest turn of the lophophore on each side subtends the antero-lateral angle of the shell.

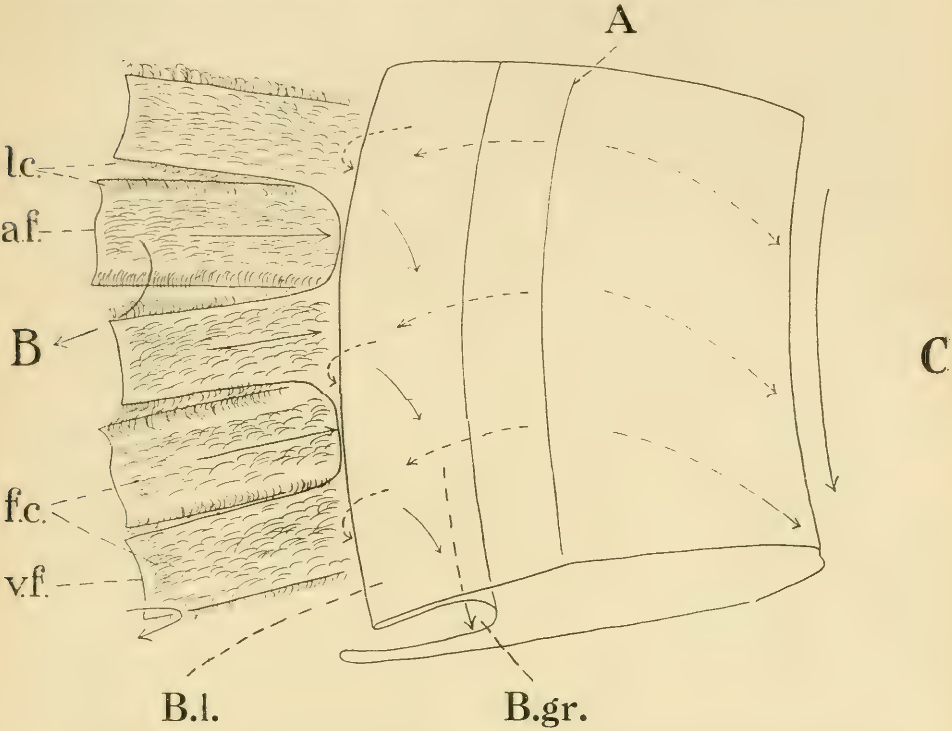

FIG. 5.—View of a portion of the lophophore, including the buccal groove and the base of five gill-filaments of Crania. Three of the filaments are ventral and two dorsal ones.

(For the sake of convenience the lophophore is magnified less than the gill-filaments. Drawn from the living object.)

The dotted arrows indicate the direction in which the cilia on the body of the lophophore lash, the arrows on the filaments the direction in which the food-collecting, the frontal cilia lash, and the thin-lined arrows below the buccal lip the direction in which the cilia lash in the buccal groove.

A.	Ridge on the lophophore away from which the cilia on both sides lash.
B.	Arrows indicating the direction in which the lateral, i.e. current-producing cilia, lash.
B.l.	Buccal lip overlying buccal groove.
B.gr.	Buccal groove along which are carried the particles from the lophophore.
l.c.	Lateral cilia.
f.c.	Frontal cilia.
v.f.	Filament of ventral series.
a.f. (d.f.)	Filament of dorsal series.

Consequently the main current is drawn into the shell at the antero-lateral angles, since the lateral cilia lash on the whole in a direction at right angles to the plane of the lophophore.

When Crania is feeding the gill-filaments are extended in the plane of the lophophore and extruded beyond the opening of the shell, as shown in Fig. 1; they are also usually kept close to the upper valve. This disposition of the filaments permits a selection of the finer food-particles, for the heavier particles in the ingoing current drop out of the stream at the entrance to the mantle cavity and are rejected by the cilia on the lower mantle as shown in Fig. 2. The main current, however, passes between the filaments on the first turn of the lophophore and onwards through the filaments of the succeeding turns of the spiral lophophore—which are superposed one above the other (see Fig. 4, p. 288)—to be passed out of the mantle cavity finally in the anterior middle portion as has been seen. Thus in traversing the mantle cavity the food-stream passes successively through a number of sieves which are formed by the tiers of filaments on the lophophoral spiral. This arrangement is probably very effective in sieving off the food-particles, although at first sight the somewhat straggling appearance of the filaments does not give this impression. The efficiency of the sieving action of the filaments, moreover, is further enhanced by the fact that the filaments are arranged in two distinct alternating rows at the edge of the lophophore (see Fig. 5, p. 289), one row being slightly behind the other, as shown in Fig. 7, which is a transverse section of a group of filaments taken near their origin from the lophophore.* As a result of this disposition the lateral rows of cilia near the base of the upper filaments lash directly on to the frontal face of the lower ones, that is, directly on to the frontal cilia, which are the principal agents in catching food-particles.

An additional minor factor in producing the main food and respiratory stream are the cilia on the body of the lophophore, which have also been figured by Blochmann. These cilia also assist partially in collecting food-particles and their action may best be gathered from Fig. 5, p. 289 and a diagram of a transverse section of the lophophore (see Fig. 6, p. 291). The cilia on the frontal surface of the lophophore are differentiated into two sets separated by a ridge running along the middle of the spiral, but slightly towards the outer, i.e. filamentar side. The cilia on the filamentar side of this ridge are very powerful and lash towards the filaments, those on the other side lash away from the ridge in a direction mainly transverse to the length of the lophophore, but also slightly oblique, towards the proximal end, as shown in Fig. 5, p. 289. The cilia on the ab-frontal face are similar to those on the frontal face (see Fig. 6, below). Thus there are two broad zones of cilia on the filamentar side of both faces of the lophophore lashing towards the filaments and so assisting in producing the food-current, and two zones lashing towards the inner edge of the lophophore, along which particles are carried around the inside of the spiral to its base. At the bases of the two arms of the lophophore the particles carried along the inner edge of the lophophore are passed on to the lower mantle, whence they are expelled from the mantle cavity.

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* The arrangement of the filaments on the lophophore is probably universal in Brachiopods, as it has been observed by Van Bemmelen in Terebratula (6) and Blochmann (10) in Crania, Discina, and Lingula. Oehlert (14) also makes the general statement that they are arranged in two rows in Brachiopods.

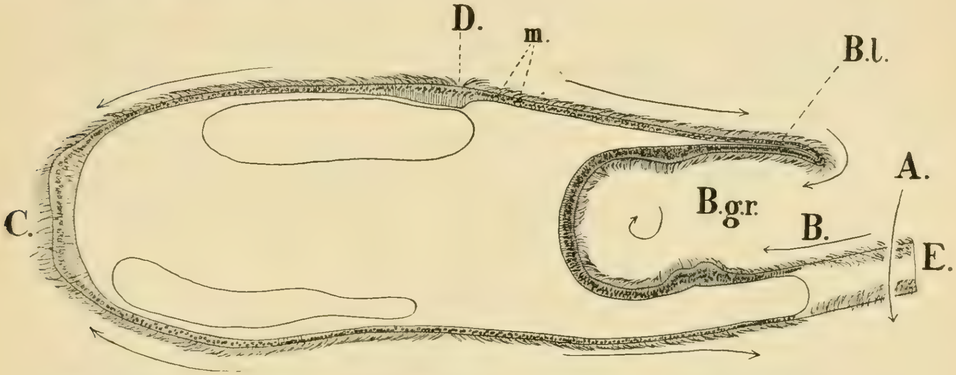

Fig. 6.—Semi-diagrammatic transverse section of the lophophore of Crania to show the difference in the action of the cilia on its various parts as indicated by the adjoining arrows.

A.	Arrow indicating the direction in which the current-producing cilia lash on the portion of the gill-filament E.
B.	Arrow indicating the direction in which the frontal cilia on the gill-filament lash.
B.gr.	Buccal groove along which food is carried to the mouth.
B.l.	Buccal lip.
C.	Inner edge of lophophore along which particles are carried to its base.
D.	Region from either side of which the cilia lash in opposite directions, resembling a watershed.
E.	Base of a gill-filament arising from the lophophore.
m.	Mucus globules.

It will now be seen that there are three factors concerned in the production of the main food and respiratory stream in Crania—and probably in most, if not all, Brachiopods—namely, the rows of lateral cilia on the gill-filaments, which are the most important factor, the cilia on the filamentar sides of the body of the lophophore, and the cilia on the mantle lobes.

Food-collection in Brachiopods is effected chiefly by the frontal cilia on the gill-filaments, and partially by the cilia on the frontal face of the outer side of the body of the lophophore. The cilia on the frontal face of the filaments collect food-particles and lash them towards the base of the filaments into the food groove (see Fig. 5, p. 289). In the same way the frontal cilia on that part of the lophophore adjacent to the food groove entrap food-particles and lash them along the face of the lophophore either on to the base of the filaments or towards the powerful cilia at the edge of the buccal lip (see Fig. 5). These cilia quickly push the particles under the lip into the food groove. The food-particles, on entering the food groove, are then carried along towards the mouth, as has been stated by Shipley, being rapidly transported thence by very strong cilia. In the process of food-collection the secretion and transportation of mucus plays an important part, for the mucus when spread out in thin layers forms an efficient method of capturing and retaining captured food-particles, and is also easily transported in this form by cilia. Mucus serving this purpose is secreted by the frontal epithelium on the gill-filaments and especially by that of the dorsal filaments, where the secreting cells occur chiefly in the trough of the filamentar groove (see Fig. 7, above, and also Van Bemmelen, 6, Taf. 8, Fig. 6, in a section of a gill-filament of *Rhynchonella psittacea*). Blochmann (10) has described aggregations of mucus cells between the bases of the filaments, that is, in the buccal groove, and also others scattered over the epithelium

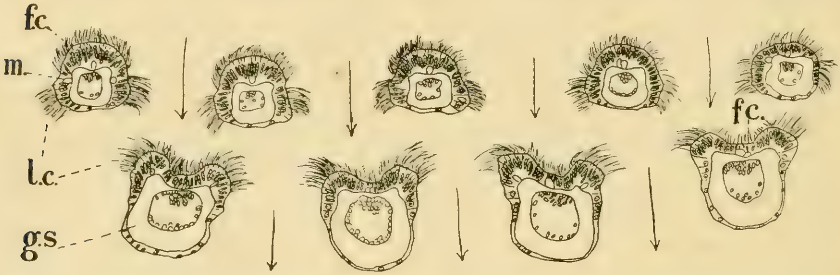

Fig. 7.—View of transverse section of five ventral and four dorsal gill-filaments of Crania taken near the lophophore, showing the alternation of the filaments in these two series.

(The outlines of the sections were drawn with the camera lucida, and the remainder filled in slightly diagrammatically (× about 192.)

The arrows indicate the directions in which the lateral cilia lash, and it will be seen that those of the smaller ventral filaments lash directly on to the frontal surface of the larger dorsal filaments.

l.c.	Lateral cilia which lash across the length of the filament, as indicated by the arrows, to produce the main current.
f.c.	Frontal cilia, which lash along the length of the filament and collect and transport food particles.
m.	Globules of mucus seen in all the sections on various parts of the frontal and lateral sides of the filamentar epithelium.
g.s.	The gill-filament supports.

of the lophophore. The secretions of these latter cells assist in a similar way to that from the filaments in the capture and transportation of food-particles.

THE CILIATION OF THE GILL-FILAMENTS OF BRACHIOPODS.

The cilia on the gill-filaments of Brachiopods are arranged in three rows along the length of the filament, as has already been described. There are, however, as Oehlert has observed, two kinds of filaments, a larger and a smaller, as is shown in Fig. 7, p. 292. The smaller ones constitute the ventral series (that is, the series facing the incoming current) on the lophophore and alternate with the larger ones in the dorsal series (see Fig. 5, p. 289). These two kinds also differ in the arrangement of the rows of cilia. On the smaller ones the lateral cilia are situated on the sides of the filaments and near the ab-frontal face, while in the larger filaments they occur similarly on the sides, but near the frontal face, except towards the tips of the filaments, where these current-producing cilia graduate towards the ab-frontal face (see Fig. 3, p. 287). The disposition of the rows of cilia is well shown in Fig. 7, p. 292, which represents transverse sections of the two kinds of filaments taken near their origin from the lophophore. In the smaller sections the filaments are shown to be nearly cylindrical and the greater part of the convex face occupied by the frontal, that is, food-collecting cilia. The larger cilia on the sides of the filaments are the lateral or current-producing cilia. Both these rows of cilia arise from columnar cells which have long elliptical nuclei. On the contrary the non-ciliated ab-frontal epithelium is composed of squarish to flattened cells with more or less spherical nuclei, and indeed it would appear that the character of an epithelium on any gill-filament forms a very good guide as to whether or not that epithelium is ciliated; if the cells in a portion of an epithelium are columnar and the nuclei elongated they probably bear cilia, whereas if the cells are squarish to squamous they are probably not ciliated. Such an interpretation of portions of an epithelium on gill-filaments may be useful in cases where it is difficult to obtain well-preserved material, for as is well known it is difficult to determine what part of an epithelium is ciliated unless such material can be obtained. One good illustration of this fact is afforded by the well-drawn figure of a transverse section of a gill-filament of Rhynchonella given by Van Bemmelen (6, Plate 8, Fig. 6). In this figure no cilia are shown at all, although the characters of the epithelium are seen to be almost identical with that of the smaller sections in Fig. 7, p. 292. A somewhat diagrammatic transverse section of a filament of Argiope is figured by Shipley (4), who depicts uniform cilia on three of the four sides of the filament. Examination of the living filaments* and sections of specially preserved material, however, would doubtless show that a differentiation of cilia occurs here as on the filaments of Crania, Rhynchonella, Terebratula, and other forms. Blochmann, however, has given beautiful figures of transverse sections of the gill-filaments of Crania, in which the differentiation of the lateral and frontal cilia is very well shown in a section of a filament of the dorsal series, but less well in that of a ventral filament. This writer also gives rougher figures of Discina and Lingula, without, however, figuring the cilia, but he remarks that the filaments of these two forms are essentially similar in their characters to those of Crania. Hence there can be no doubt that the gill-filaments of all Brachiopods have cilia disposed and differentiated in the same way as in Crania.

SUMMARY OF CURRENT-PRODUCING MECHANISMS AND THE MODE OF FEEDING IN BRACHIOPODS.

The main current through the mantle cavity in Brachiopods is produced chiefly by the lateral cilia on the gill-filaments and partially by cilia on the mantle and on the body of the lophophore. The disposition of the lophophore and the filaments on the lophophore is such that two ingoing currents of water are established at the sides of the mantle cavity. On each side the current passes between the filaments of the first turn of the lophophore and outwards through the filaments of the second and succeeding turns of the lophophoral spiral into the median dorsal region of the mantle cavity. At this point the currents from each side meet and pass out of the mantle cavity at the middle of the anterior region of the shell.

The food-particles brought into the mantle cavity in the main stream are caught by the frontal cilia on the gill-filaments, and by those on the outer frontal portion of the lophophore, and transported by these cilia into the buccal groove. In the buccal groove the food-particles are lashed rapidly along to the mouth by the strong cilia on the buccal lip and fused bases of the filaments. It seems probable that the food-stream in Brachiopods is effectively sieved by the gill-filaments, since besides collecting food-particles the ventral ones lash directly on to the food-collecting face of the lower filaments which alternate with them: moreover, part of the food-stream is repeatedly sieved in most forms by the filaments on the superposed whorls of the lophophore.

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* Subsequent examination of living Argiope from Naples has shown this statement to be correct.

In Crania a selection of the finer food-particles is effected in the following manner: the ingoing currents are drawn into the dorsal portion of the mantle cavity, hence when the dorsal valve is uppermost—as frequently happens—the heavier particles drop on to the ventral mantle, whose cilia discharges them either outside the mantle cavity or carries them to the edge of the mantle, whence they are shot away by the animal suddenly clapping together the valves of the shell. Modifications in the manner of rejecting unsuitable food-particles probably occur in other Brachiopods in much the same way as has been observed in Lamellibranchs (1, pp. 457 to 463).

AN EXPLANATION OF SOME MORPHOLOGICAL CHARACTERS IN FOSSIL AND RECENT BRACHIOPODS.

In the foregoing description it has been shown that in certain Brachiopods, as, for example, Crania, there is a physiological subdivision of the main part of the mantle cavity into right and left portions, and it would seem highly probable that in all Brachiopods there is a similar subdivision of the mantle spaces, since the disposition of the lophophore is fundamentally similar in them all. Unfortunately few observations have been made on the nutritive currents of Brachiopods, but those of Morse on Lingula (7, p. 157) are of interest. Morse found that Lingula lives embedded in sand, and that "while partially buried in the sand the anterior border of the pallial membranes contract in such a way as to leave three large oval openings, one in the centre and one on each side. The bristles, which are quite long in this region of the animal, arrange themselves in such a way as to continue these openings into funnels and entangle the mucus which escapes from the animal; these funnels have firm walls. *A continual current is seen passing down the side funnels and escaping by the central one.*"* These observations have been confirmed by François (8) in so far as he figures the trilobed apertures of the burrows of this animal (see also *Camb. Nat. Hist.*, Vol. 3, Fig. 321). Thus there can be little doubt that the mantle cavity is subdivided in Lingula in the same way as in Crania.

In these respects it is a highly interesting fact that many Brachiopods both recent and fossil have a trilobed shell whose apertures correspond to the inlets for ingoing currents and the outlet for the outgoing current (see Fig. 8 C, p. 296), but it is probably still more interesting and remarkable that in some forms, as in *Conchidium Knighti*, the mantle cavity is practically subdivided into right and left portions by a median septum, and that in others, as in *Terebratula janitor*, the shell is actually divided into two wings (see Fig. 8 A and B, below). In all Brachiopods there would thus appear to be little doubt of the physiological independence of the right and left halves of the mantle cavity. Hence variations in the direction of formation of antero-posterior median septa, as shown in Stringocephalus, Conchidium, and many other genera, of trilobation of the shell, as shown in many Rhynchonellidæ, and bilobation of the shell, as shown in *Orthis biloba*, *Terebratula diphya*, and other forms, do not interfere with the functions of the two portions of the lophophore, and it is conceivable that these variations may be advantageous to certain forms under certain conditions.

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* The italics are mine.

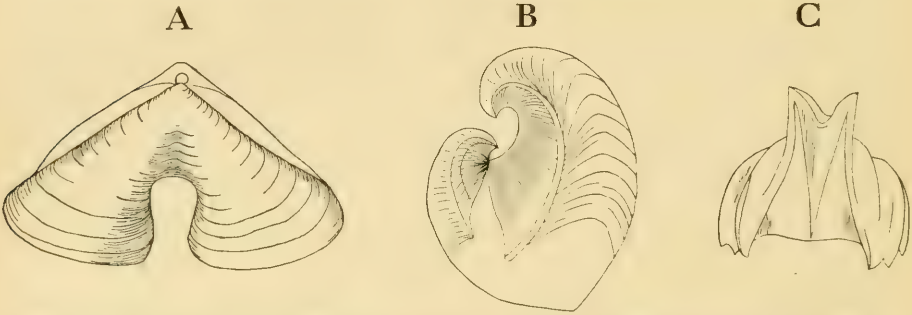

Fig. 8.—Views of types of Brachiopod shells showing morphological division of the mantle cavity into right and left portions, and trilobation of the shell.

A. Shell of *Terebratula* (*Pygope*) *janitor* (after Oehlert) in which the mantle cavity is almost entirely divided into two separate compartments.

B. View of interior of shell of *Conchidium Knighti* (after Davidson) showing internal partial subdivision of the mantle cavity by the septa which are shaded.

C. Frontal view of the shell of *Rhynchonella cynocephala* (after Oehlert), showing the anterior median portion of the shell produced into a sort of siphon in the region in which in other Brachiopods (for example, Crania and Lingula) is expelled the outgoing current.

The disposition of the lophophore in the Spiriferidæ indicates that the main ingoing current entered the mantle cavity in the front middle portion and was expelled in two outgoing currents at the postero-lateral angles of the shell, a condition exactly the reverse of that obtaining in Crania, where the ingoing current is twofold and the outgoing current single. Thus the production of the shell—frequently occurring in this group—into postero-lateral angles, somewhat like those occurring in modern Pectens, may have served as a sort of siphon for carrying away the exhalent streams.

COMPARISON OF THE CILIARY MECHANISMS ON THE GILLS OF GASTROPODS, LAMELLIBRANCHS, AMPHIOXUS, AND BRACHIOPODS.

The ciliary mechanisms concerned in producing the main food and respiratory current in Gastropods, Lamellibranchs, Amphioxus, Ascidians, and Brachiopods have now been shown to be essentially similar in all these groups (see preceding pages and Orton, 1* and 2, and Herdman, 9). The main current is produced in all groups alike chiefly or entirely by the rows of cilia, the lateral cilia situated at the sides of the gill-filaments (see Fig. 9, p. 299) : for the term " gill-filament " may be used as well for the gill-bars of Amphioxus or Ascidians and the lophophoral cirri of Brachiopods as for the elements of the ctenidium of Gastropods and Lamellibranchs. These rows of lateral cilia lash across the length of the gill-filaments in all cases and set up a current towards and at right angles to the gill. The current thus produced brings into the mantle cavity—or the branchial sac in the case of the Protochordata—food-particles, which serve for the nourishment of the animal, and also brings the means for oxydation of the tissues, while the expulsion of the current from within the cavities of the animals serves to carry away the waste products resulting from the various activities of the organisms.

The food-particles carried in the main current into the spaces of all these animals are arrested on the gill which is necessarily interposed between the ingoing and outgoing currents, and acts like a sieve. The actual collection of food-particles varies somewhat in the different groups. Food-collection is effected chiefly, however, in all the groups by means of rows of cilia on those faces of the filaments facing the oncoming current, that is, on the frontal faces. In some Lamellibranchs—which are curiously distributed throughout the group, as Nucula, Solenomya, Anomia, Mytilus, Cardium, Ostrea, Tapes—there are additional food-collecting cilia on the latero-frontal edges of the gill-filaments. These latero-frontal cilia are true straining cilia, and lash across the length of the filament at right angles to the oncoming current and away from the inter-filamentar spaces. In this way they pass particles on to the frontal cilia, and indeed are so numerous in these animals as to give the appearance of flexible combs working along the sides of the filaments. The frontal cilia in all forms lash the food-particles into a food-groove, whence the particles are carried to the mouth or œsophagus. It is an interesting fact that the frontal cilia are in all cases short, as compared with the length of the lateral or the latero-frontal cilia, and it is probable that short cilia would be much more effective than long ones in transporting food-particles and masses of particles embedded in mucus, and would, moreover, be more easily controlled and less liable to become intermixed and so interfere with their fellows.

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* In a paper written in 1910 Bourne (11) states of the lateral cilia of the Gastropod *Incisura* (*Scissurella*) *lytteltonensis* that he does not think " that their function is to hold the filaments together, but simply to create currents over the surfaces of the filaments." I hasten to give this reference because I only became aware of it after my paper on the ciliary mechanisms in Gastropods was published. From the researches described in that paper it is now seen that there is an element of truth in the suggestion made by Bourne.

Food-collection is also assisted in some Gastropods as in Crepidula, and some Lamellibranchs as in Nucula, by rows of cilia on the ab-frontal faces of the filaments, but probably the function of these rows of cilia in assisting in producing the main current is more important than that of food-collecting. In Amphioxus and Ascidians cilia on the epithelium of the atrial cavity help in a small way in producing the main stream.

The distribution of the cilia on the gill-filaments of Gastropods, Lamellibranchs, Amphioxus, and Brachiopods is shown in the transverse sections depicted in Fig. 9, p. 299. From these figures the essential similarity of all the filaments is at once apparent. The position of the lateral cilia is, however, somewhat different in the types of filament represented by those of Crepidula and Crania. In those filaments the lateral cilia occupy a position much nearer the ab-frontal surface of the filament. It is probably significant that in both Crepidula and Crania the gill-filaments are free and without any extensive interlocking arrangements such as exist in Lamellibranchs, or such a consolidation as occurs in Amphioxus and Ascidians. It is very probable therefore that the receding of the lateral cilia from the frontal surface in these forms is an effort to compensate for the lack of compactness in the gill, by exposing a larger food-collecting, that is, frontal surface.

A glance again at Fig. 9 shows that in all these filaments internal supports (g.s.) are developed similarly, but with some differences in order to maintain the gills sufficiently rigid in the form of either an open basket-work or grid-iron sieve.

In an earlier paper (2) it has been suggested that the function of the gill in Crepidula, most Lamellibranchs and Amphioxus is merely that of a water-pump and a food-sieve, and that the respiratory function is not performed to any appreciable extent on the gill in these forms. In Brachiopods, Shipley (4, p. 501) has arrived at the same conclusion with regard to the function of the lophophore, of which he states: "I have been unable to detect any blood corpuscles in the tentacles, and I believe

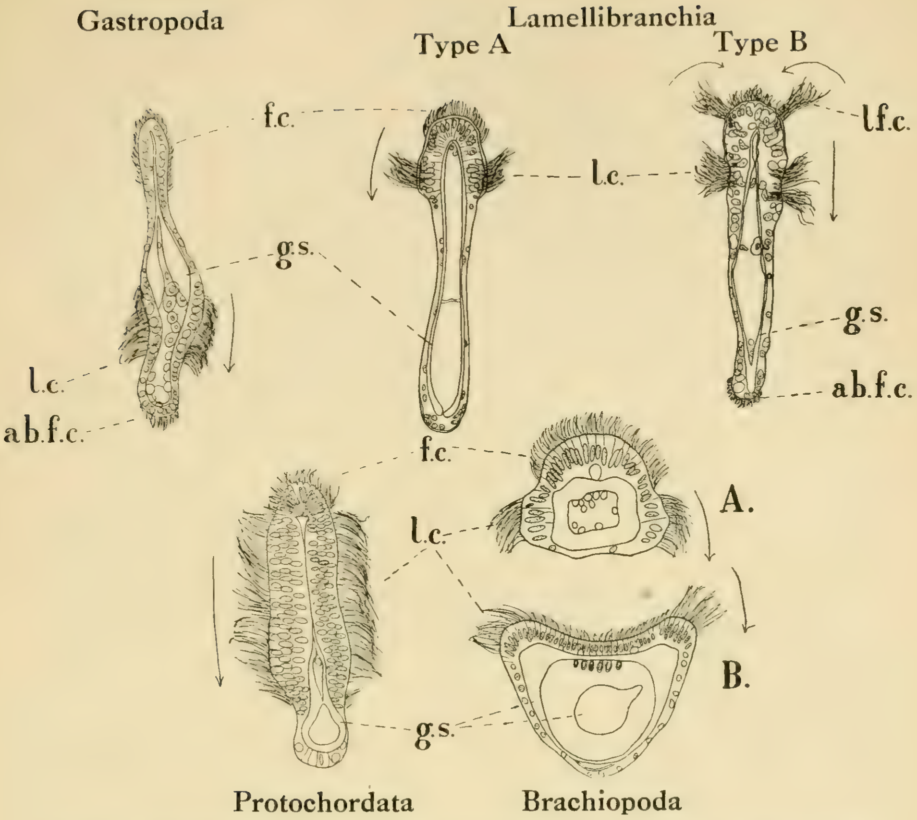

FIG. 9.—Transverse sections of the gill-filaments of members of Gastropods, Lamellibranchs, Protochordata, and Brachiopods, illustrating the essential similarity of the ciliation of the filaments in all these groups. (Variously magnified.)

l.c.	Lateral cilia which produce the main food and respiratory current in all the groups.
f.c.	Frontal cilia which are the main food-collecting cilia in all the groups.
l.f.c.	Latero-frontal cilia, which are special food-catching cilia present only in some Lamellibranchs, as Nucula, Anomia, Mytilus, Cardium, and others; they lash in the direction shown by the adjoining arrows.
ab.f.c.	Ab-frontal cilia present and well developed in Gastropods and some Lamellibranchs, but less well developed in Amphioxus and Ascidians; absent in Brachiopods. These cilia assist both in food-collection and in producing the main current.
g.s.	Internal supports for the gill-filaments and present in all the groups, but additional support by calcareous spicules is given in some Brachiopods, as in *Terebratula vitrea*, shown in the Brachiopod section B.

In the above types of gill-filaments Gastropods are represented by a transverse section of a filament of *Crepidula fornicata;* Lamellibranchs by two sections representing the two types of ciliation in this group. Type A is of *Glycimeris glycimeris*, and would serve equally well for Pecten, Arca, and others. Type B is of *Mytilus edulis*, and represents Nucula, Solenomya, Anomia, Cardium, Ostrea, Anodon, and many others. Protochordata are represented by a section of a secondary gill-filament of *Amphioxus lanceolatus*, but sections of Ascidian and Enteropneustan (as represented by Ptychodera) gill-filaments are essentially similar to that of Amphioxus in their ciliation.

The two kinds of filaments present in Brachiopods are represented by the Brachiopod sections A and B. The section A is of a ventral filament of *Crania anomala*, and B is of a dorsal filament of *Terebratula vitrea*. The latter section is slightly idealized in that the supporting spicules present within the chitinous gill-support are represented in the drawing although dissolved out of the actual section by the fixative.

the sole function of the lophophore is to set up a stream by means of its cilia, and so to bring diatoms and other articles of food to the mouth, and that it has no respiratory function whatever. Indeed, it is difficult to imagine how an interchange of gas could take place through the thick, dense layer of supporting substance."

There would appear to be little doubt that Shipley is correct, hence in practically all the members of the above-mentioned groups the gill probably functions merely as a water-pump and a food-sieve. In Crepidula, most Lamellibranchs and Brachiopods respiration doubtless occurs mainly in the mantle; while in Amphioxus a gaseous exchange is probably effected chiefly in the cœlomic spaces adjacent to the atrium. In Ascidians respiration is doubtless effected in the branchial sac.

In all these gills there can be no doubt that mucus formation plays a very important part in the process of food-collection. It has been shown in an earlier paper (2) that in Amphioxus and Ascidians the mucus formed in the endostylar groove of these animals is thrown on to and transported along the gill-filaments in thin sheets to serve for entrapping food-particles. In Lamellibranchs and Crepidula it has been suggested that the corresponding mucus formation takes place in the frontal epithelium of the gill-filaments, and indeed swollen cells, which are almost certainly mucus cells, have already been figured in the epithelium of the filaments of Mytilus (see I, Fig. 17, *passim*). Similar globules occur also in the filaments of Glycimeris, Crania (see Fig. 9, p. 299), Terebratula and Rhynchonella (see 6). It is hoped to make this important problem the subject of a special investigation.

The writer's work, however, on the endostyle of Amphioxus suggested the probable function of a previously enigmatical glandular organ situated along the base of the gill-filaments of Crepidula. An examination of the living animal confirmed the suggestion that this organ is indeed an *endostyle*, as may be gathered from the description of it in the section on p. 303.

It is an interesting fact that the spines (clavulæ) composing the fascioles of the heart-urchins, Echinocardium and Spatangus, have been found to have the cilia disposed in definite rows along their sides in a manner very similar to that in which the lateral cilia are distributed on the gill-filaments of all the above-mentioned groups. These rows of cilia on the spines do, as a matter of fact, very closely resemble the lateral cilia of gill-filaments in that they lash in a definite direction and with the same wave-like motion characteristic of those current-producing cilia; they are also situated on opposite sides of the spines, and are indeed current-producing cilia analogous to those of Gastropods, Lamellibranchs, Ascidians, Amphioxus, and Brachiopods.

The function of these spines is being investigated further, and figures will be given to show their resemblance to gill-filaments. MacBride, however, is doubtless correct in stating (*Camb. Nat. Hist.*, Vol. I, p. 550) that: "Between the two posterior petals (in *Echinocardium cordatum*) there is a hoop-shaped band of very small black spines. These spines are ciliated, and draw a current of fresh sea-water over the respiratory tube-feet. Beneath the periproct there is a similar band called the 'sub-anal fasciole'; this probably produces a current of water which sweeps away the material ejected from the anus."

THE CILIARY MECHANISMS ON THE GILLS OF CRYPTOCEPHALOUS POLYCHÆTES AND ON THE LOPHOPHORE OF PHORONIS.

An examination has also been made of the cephalic gills of various Cryptocephalous Polychætes. It has been found that these gills are used for the purpose of feeding, and that the ciliary mechanisms concerned in the feeding process in—for example—Spirorbis, Pomatoceros, Hydroides, Branchiomma, Sabella, and Filograna are identical with those on the gills of Lamellibranchs, some Gastropods, Amphioxus and Brachiopods, that is to say, there are well-differentiated current-producing lateral cilia and food-collecting and food-transporting frontal cilia on the pinnules of the tentacles. Food is very rapidly collected in these Polychætes and transported along the pinnules to the axes of the tentacles and thence to the mouth. Further particulars and figures with regard to these animals will, however, be given later.

The lophophoral cirri of Phoronis have also been investigated, but up to the present it has only been possible to examine the living animal cursorily. Nevertheless this short examination revealed the facts that in this animal also the cirri—or gill-filaments—are differentiated into lateral and frontal rows, and that a good current of water is drawn towards the mouth within the space enclosed by the lophophoral cirri. The functions of the lateral and frontal cilia in Phoronis, however, do not appear to be identical with those of the similar cilia in Brachiopods and the other groups mentioned above, but a more complete examination of the living animal will be made later with a view to investigating fully the ciliary mechanisms concerned in process of feeding in this animal.

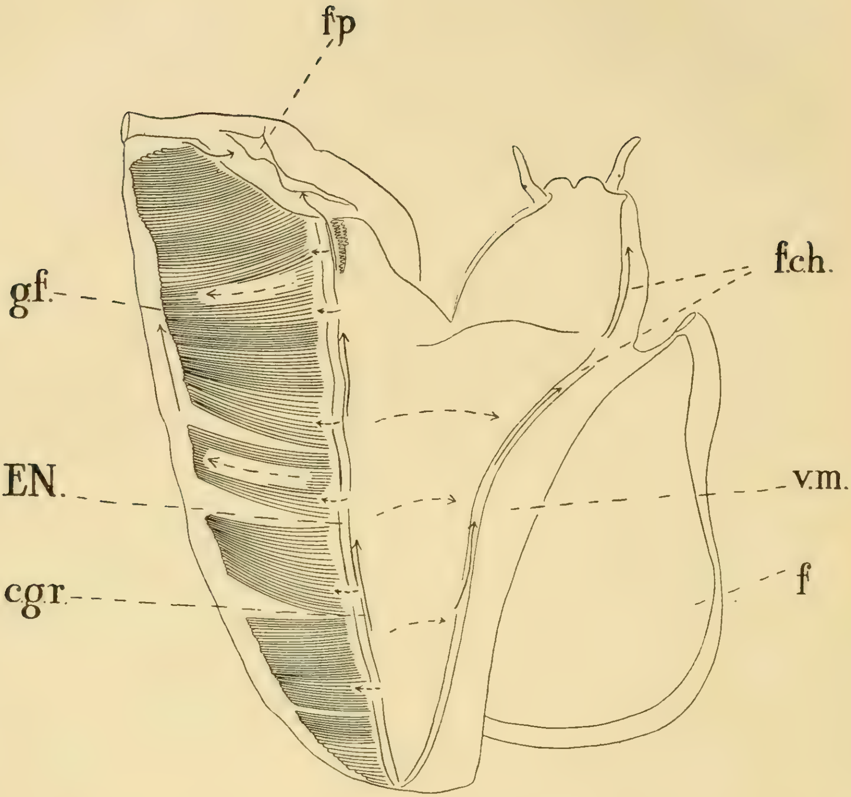

FIG. 10.—View of the mantle cavity and gill of Crepidula, showing the endostyle at the base of the gill. (The animal has been taken out of its shell and the mantle turned over to the left.)

The dotted arrows on the endostyle, En, indicate the directions in which mucus is lashed from the endostyle on to the base of the gill-filaments.

EN.	Endostyle from which mucus and food-particles are lashed on to the gill-filaments.
c.gr.	Ciliated groove along the left side of the endostyle carrying mucus forwards to the food-pouch, as indicated by the complete arrows.
f.p.	Food-pouch in which the heavier food-particles become lodged.
f.ch.	Food-channel on the right side of the body extending along the visceral mass and the " neck " region of the animal towards the mouth. In this channel is collected the main mass of collected food-particles which are carried in the direction indicated by the arrows.
f.	Foot.
v.m.	Visceral mass.
g.f.	Gill-filaments.

THE ENDOSTYLE OF CREPIDULA AND CALYPTRÆA.

At the base of the gill-filaments of Crepidula and Calyptræa there is a group—or rather there are two groups—of large glandular ciliated cells which secrete a mucoid substance (see Figs. 10 and 12, p. 304). Examination of the living gill and the surrounding parts shows that the cilia of these glandular cells lash the secreted mucus on to the bases of the gill-filaments, whence it is passed along the face of the gill to be used for the purpose of entrapping food-particles (see Figs. 10 and 11, above), as has already been

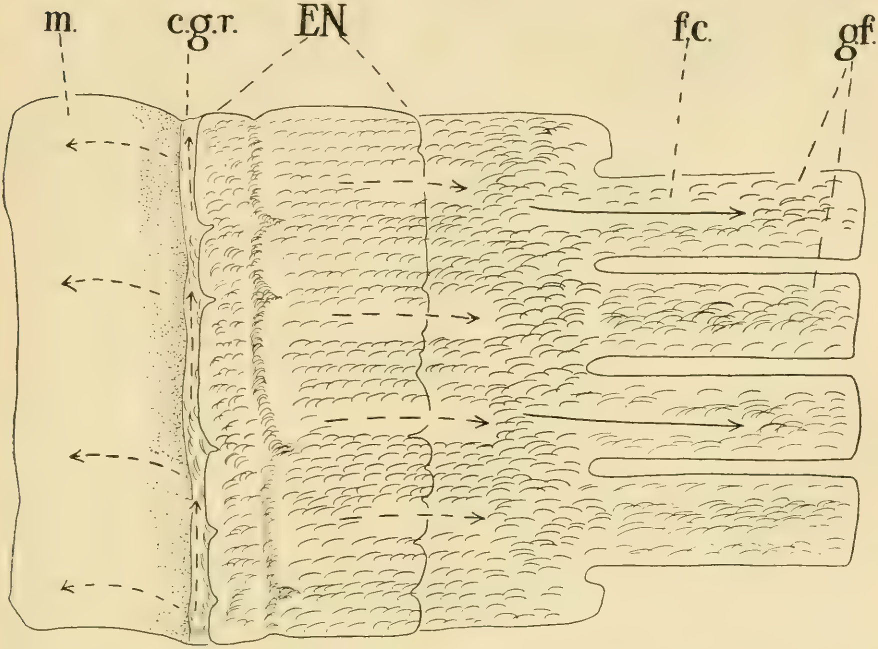

FIG. 11.—View of the endostyle and the bases of four gill-filaments of *Crepidula fornicata* highly magnified. (Drawn from the living object.)

The dotted arrows on the endostyle, EN, and the complete ones on the bases of the gill-filaments indicate the direction in which mucus is passed from the endostyle on to the bases of the gills. The dotted arrows on the mantle on the floor of the inhalent chamber, m, show the direction in which the cilia in this region lash. Similarly the forward stream in the ciliated groove, c.gr., on the left of the endostyle is indicated by the overlying dotted arrows.

EN.	The endostyle consisting of two rows of gland cells between and to the left of which are rows of specially differentiated ciliated cells.
c.gr.	Ciliated groove on the left of the endostyle.
g.f.	The bases of the gill-filaments.
f.c.	Frontal cilia of gill-filaments.
m.	The mantle covering the floor of the inhalent chamber.

described in this Journal (1, pp. 448, 455). I thought formerly that this mucus was secreted by the epithelium of the gill-filaments (loc.cit.), but there is no doubt now that the greater part is secreted by the glandular cells at the base of the filaments, although it is not unlikely that a certain amount of mucus may be secreted by the epithelium of the gill-filaments. These groups of grandular cells may be properly termed an *endostyle*, since they

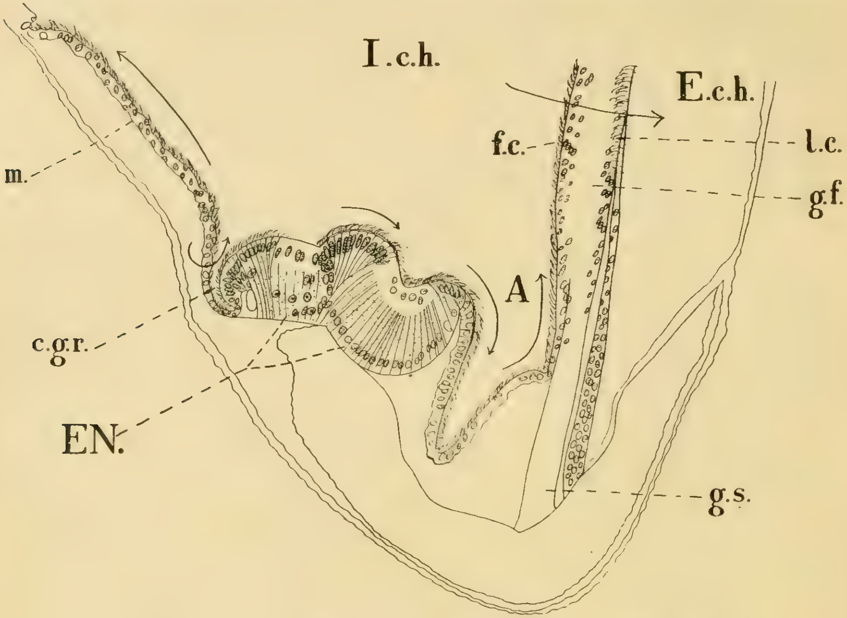

Fig. 12.*—Transverse section of the endostyle of Crepidula (× about 105).

A.	Arrow indicating the direction in which the mucus from the endostyle is passed on to the base of the gill-filaments.
EN.	Two rows of groups of gland cells in the endostyle, between and to the left of which is a group of ciliated cells with apical nuclei.
g.f.	Gill-filament.
f.c.	Frontal epithelium and frontal cilia on gill-filament.
l.c.	Lateral cilia on gill-filament.
g.s.	Gill-filament support.
c.gr.	Ciliated groove to the left side of the endostyle.
m.	Epithelium of mantle the cilia on which lash towards the main food-channel on the right side of the body as indicated by the arrow placed alongside.
I.ch.	Inhalent chamber.
E.ch.	Enhalent chamber into which the main current is passed from the inhalent chamber as indicated by the arrow crossing the gill-filament.

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* I am indebted to Mrs. Orton for the drawing for this figure as well as those for figures 1, 2, and 8, and also for assistance with all the other drawings except that for Fig. 3; and also to Mr. E. Ford for kindly lettering Figs. 3, 4, 6, 7, 9 to 12.

have the same function as the similar groups of glandular cells in a similar position in Amphioxus and Ascidians. The cilia on the endostyle of Crepidula and Calyptræa lash mucus and food-particles on to the gill as has already been stated, but there is also a ciliated groove on the left side of the endostyle which lashes some mucus and captured food-particles forwards (see Fig. 10). This forward stream of mucus contributes largely to the forward stream in the mantle cavity which has already been described (1, p. 448), and whose function is chiefly that of entrapping the coarser food-particles at the entrance to the inhalent chamber. By means of the mucus which is thus carried along this ciliated channel a large proportion of the larger and often innutritious particles become lodged in the food-pouch in the middle of the front portion of the mantle, and are either rejected or eaten by the animal, as has already been observed (1, p. 448). In this way and to this extent these animals are able to select their food.

The character of the endostyle of Crepidula may be gathered from the views shown in Figs. 10 and 11, and the transverse section shown in Fig. 12. From the transverse section it is seen that there are two rows of long glandular cells with basal nuclei, and between and to the left of these rows is a line of curious ciliated cells with an apical or distal nucleus. On either side of the endostyle, the epithelium consists of columnar ciliated cells, which become more cubical as they recede from the endostyle. The epithelium on the right side (seen on the left in the section) passes into that of the floor of the mantle cavity. In the latter region the cilia lash away from the endostyle towards the right side of the mantle cavity, and while thus assisting in producing the main current, at the same time help in collecting food-particles into the food-groove on the right side of the floor of the mantle cavity (see Fig. 10, p. 302). The characters of the endostyle and the ciliation of the mantle are the same in Calyptræa as in Crepidula. In Capulus these characters are also the same in the living animal, but sections of the endostyle have not yet been examined.

The remarkable likeness of the endostyle of Crepidula and its allies to that of Amphioxus and Ascidians becomes still more evident when it is compared—as it should be—to a half, the right half, of that of Amphioxus and Ascidians: for it is to be remembered that there is only one half of a ctenidium and only one series of filaments present in Crepidula, whereas both a right and left series of "filaments" exist in Amphioxus and Ascidians. When, therefore, the endostyle of Crepidula is compared with the right half of that of Amphioxus and Ascidians it will be seen that in both there are two rows of similar long glandular cells with basal nuclei, separated by a row of ciliated cells with apical nuclei. The function of the intermediate row of ciliated cells in Amphioxus has been shown to be that of passing on to the gill the mucus formed by the gland cells (see 2, Fig. 3, and p. 25), and the function of the corresponding cells in the endostyle of Crepidula is the same.

It has now been shown (1) that the endostyles in Amphioxus, Ascidians, and Crepidula, and its allies * show a remarkable resemblance, and also that the ciliation and internal supports of the gill-filaments in Gastropods, Lamellibranchs, Amphioxus, Ascidians, and Brachiopods are essentially the same. Consequently it is clear that the homological † value of any of those characters cannot be great since they are present in widely divergent groups, and indeed would appear to be merely similar adaptations to a similar method of feeding. Therefore it follows that organs present in different animals, but having the same functions, are never necessarily homologous, since practically identical organs are here shown to occur with the same function in groups which are undoubtedly only remotely related. These groups are indeed so remotely related that the characters of the ciliation and internal supports of the gill-filaments, on the one hand, and the endostyle in Crepidula and in the above-mentioned Protochordates,‡ on the other hand, must have arisen independently in each case to meet similar requirements. Such plasticity in organisms is indeed remarkable, and its demonstration necessarily increases the difficulties in the already difficult problem of determining what organs in different animals really are genetically related. For instance, the presence of an endostyle in Crepidula confounds all the arguments that we can advance at present in support of the theory that the parabranchial ridges of the Enteroprensta are homologous with the endostyle of Amphioxus (see Willey, 15). These organs may possibly be homologous, but we have no means of determining with any certainty that they really are: and a similar uncertainty must exist in other similar cases.

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* It is not improbable that an endostyle may be present also in many other aquatic Gastropods.

† The term Homology is used with the meaning Lankester gives to the term Homogeny (see 16).

‡ It is not contended that the endostyle has arisen independently in Amphioxus and Ascidians, for the well-known reason that development in the latter group indicates a not extremely remote relationship of that group with Amphioxus.

COMPARISON OF THE ADAPTATIONS IN BRACHIOPODS AND LAMELLIBRANCHS TO THE PROCESS OF FEEDING.

The general resemblance of the shell and mantle lobe in Brachiopods and Lamellibranchs, as well as the general similarity of their feeding organs, renders a comparison of the adaptations in these groups to the process of feeding a matter of some interest. It has been shown in an earlier work (1, p. 463) that it is highly probable that Lamellibranchs have evolved in the direction of perfecting the gill as a feeding organ. In all Brachiopods, so far as is at present known, the feeding organ, the lophophore with its gill-filaments, is in a condition comparable with that of the lower Lamellibranchs, namely, the Protobranchia and the more lowly Filibranchia. No process of fusion of the filaments appears to have taken place in any Brachiopod similar to that generally recognised as having occurred in Lamellibranchs. Since in the latter group this process of fusion appears to have been one of the main factors governing the evolution of that group, the absence of such a process of fusion in Brachiopods may very probably be one of the factors which has resulted in the present decadent condition of that group. Along with the absence of fusion of the gill-filaments in Brachiopods are correlated the absence of fusion of the mantle lobes and the formation of siphons, both of which characters are in many cases of prime importance in the feeding process. Doubtless other disadvantages under which Brachiopods suffer—in comparison with Lamellibranchs in general—are the absence of a locomotory organ in the adult stage represented by the foot in Lamellibranchs, and the sedentary life necessitated in Brachiopods by their structure. These two factors debar Brachiopods from the liberty Lamellibranchs mostly have of moving about, and so being able to place themselves to some extent in a suitable environment. Thus, therefore, probably the sum of these disadvantages may account in some measure for the decadence of the group of Brachiopods, as compared with the flourishing condition of Lamellibranchs at the present day.

It has been shown that the mantle cavity in Brachiopods is physiologically and sometimes morphologically divided into two compartments. This condition is absent in Lamellibranchs, where the mantle cavity in all forms is physiologically entire. It is true that in all Lamellibranchs the mantle cavity is divided either temporarily or permanently into inhalent and exhalent chambers by the gill (see 1), but a corresponding temporary division occurs in *both* compartments of the Brachiopod shell when the animal is feeding. The nearest approach in Brachiopods to the siphonate forms in Lamellibranchs is probably represented by members of those genera in which the postero-lateral angles of the shell are very much drawn out, as in *Productus giganteus, Spirifer verneuilli*, and species of Leptæna and Platystrophia, and in other forms common in the Rhynchonellidæ, in which the front middle part of the shell is differentiated from the rest in such a way as to resemble a siphon (see Fig. 8, C, p. 296). In all these forms it is highly probable that the shell modifications are correlated with localization of the food-currents. Lingula, however, has been shown by Morse (7) to dispose the mantle setæ in such a way that they form a sort of temporary siphon for the ingoing and the outgoing currents, and this method of forming siphons may occur in other Brachiopods.

From the description of the Brachiopod lophophore given in the preceding pages there can remain no doubt that that organ is analogous to the gill of Lamellibranchs, as has indeed already been observed by Lankester (12). The resemblance in appearance of the lophophore to the palp of a Lamellibranch such as Nucula is indeed close, but that the resemblance is superficial will have been seen from the foregoing account of its function. Hence, if the organs can be compared at all Morse is undoubtedly wrong in comparing the lophophore as he does (13) with the Lamellibranch palp. Thus it is seen that on the whole the parallel developments of organs in the Brachiopods and Lamellibranchs are much fewer than might have been expected from the similarity in their mode of feeding, and the differences which do exist may probably be very largely due to the absence in Brachiopods of that consolidation of the gill-filaments which appears to have played such an important part in the evolution of the Lamellibranchs.

SUMMARY.

Brachiopods feed in the same way as some Gastropods, as, for example, Crepidula, most Lamellibranchs, Amphioxus, and Ascidians, that is, by establishing a current of water through certain spaces bounded by the body, and sieving off the food-particles contained in that current by means of the lophophore and its cirri.

The cilia on the gill-filaments (cirri) are differentiated in Brachiopods into *lateral* and *frontal* cilia, in essentially the same way and with the same functions as in some Gastropods, most Lamellibranchs, Amphioxus, Balanoglossus, and some Ascidians.

The main current through the mantle cavity in Brachiopods is produced chiefly by rows of *lateral cilia* on the cirri, or gill-filaments, but cilia on the body of the lophophore and on the mantle assist in maintaining this current, which in Crania enters the mantle cavity in the antero-lateral regions of the shell at each side and is expelled in the middle front part of the shell. The mantle cavity in Brachiopods is divided physiologically into two compartments corresponding to the bilateral symmetry of the lophophoral spirals. In some Brachiopods the mantle cavity is also divided morphologically into two compartments, either by medium antero-posterior septa or by actual bifurcation of the whole shell.

Food-collection is effected in Brachiopods mainly by the frontal cilia on the gill-filaments, but tracts of cilia on the filamentar side of the lophophore assist in capturing food-particles. The captured food from both these sources is passed into the well-known food-groove on the lophophore and thence to the mouth.

For the capture of food-particles mucus is secreted on the frontal epithelium of the gill-filaments, at the bases of the gill-filaments, and on the body of the lophophore. A selection of the finer food-particles is effected in Brachiopods to some extent in the lower parts (inhalent chambers) of the mantle cavity ; the heavier undesirable particles being collected on the mantle lobe from which they are expelled from the precincts of the animal.

Some of the characters of the shells of many fossil and recent Brachiopods can be partially explained from the fact of the physiological subdivision of the mantle cavity.

The cephalic gills of Cryptocephalous Polychætes have current-producing lateral cilia and frontal food-collecting cilia essentially similar to those of Brachiopods, Lamellibranchs, and the other groups mentioned above. In Phoronis there is also a similar differentiation of cilia on the lophophoral cilia, but so far as this animal has been examined the functions do not appear to be quite the same as in the other groups examined.

Thus the ciliary mechanisms on the gills of many Gastropods, most Lamellibranchs, Amphioxus, Ascidians, Brachiopods, and the Cryptocephalous Polychætes are essentially similar, and in the three groups to which these animals belong the same mechanism—and similar gill-filament supports—have arisen independently to meet similar or the same requirements, and thus afford an interesting example of parallel evolution.

An endostyle is present at the base of the gill in Crepidula, Calyptræa, and probably also in Capulus. This endostyle of Crepidula shows a remarkable resemblance to that of Amphioxus and Ascidians and serves the same purpose, that is, it secretes mucus which is passed on to the gills for the entrapping and the transportation of food-particles. On the right side of the endostyle of Crepidula is a ciliated groove, which carries mucus and some food-particles forwards to serve for catching and expelling the heavier food-particles which enter the front portion of the inhalent chamber.

The independent origin of essentially the same ciliary mechanisms in Molluscs, Protochordata, Brachiopods and some Polychætes, and of a similar glandular organ, the endostyle in Crepidula and Amphioxus and Ascidians, are facts which add greatly to the difficulty of determining with any certainty what are homologous organs in different animals. It also follows that similar organs occurring in different animals and having the same function are never necessarily homologous.

The adaptation in Brachiopods and Lamellibranchs to the process of feeding are compared, and the suggestion is made that the present decadent condition of the former group is due to the absence of that consolidation of the gill and correlated modification of the mantle which appear to have conduced to the present relatively flourishing condition of the Lamellibranchs.

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Preliminary Account of a Contribution to an Evaluation of the Sea.

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TABLE OF CONTENTS.

PAGE
Introduction 312
Rate of Growth in some Cœlenterata 313
Rate of Growth in some Porifera and the life-history of Sycon, Grantia, and Leucosolenia 314
Rate of Growth in some Platyhelminthes 316
Rate of Growth in some Annelida 316
Rate of Growth in some Polyzoa 316
Rate of Growth in some Crustacea 317
Rate of Growth in some Mollusca 318
Rate of Growth of *Crepidula fornicata* 320
The age of sex-change in *C. fornicata* 322
Rate of Growth of Oyster spat in the first summer 323
The life-history of *Galvina picta* 323
The life-history of Ciona, Clavellina, and Ascidiella 324
Rate of Growth in some other Tunicates 325
Rate of Growth in *Saccorhiza bulbosa* 326
Summary 326

INTRODUCTION.

An investigation of the rate of growth in Marine Invertebrates was begun in 1911, and a large amount of material the age of which is known has now been collected from various sources. The particular objects of this research are: (1) to establish the age of common marine invertebrates, (2) to determine the minimum age at which these forms begin to breed, (3) to examine the rate of growth at different seasons of the year and under different conditions, (4) to investigate the fecundity of different forms so far as possible, and (5) to collect the scattered literature on these subjects.

The investigations have been carried on mainly by immersing various objects in the sea at a known time and subsequently observing and collecting the various kinds of animals growing on them. Other experiments, however, are being carried out with some success with the object of entrapping young or larval free-living animals and observing their rate of growth. The sexual condition of the collected animals has been noticed particularly, and evidence of the maturity of the sexual products obtained either by isolating the animals or by trying artificial fertilisations. As a result of these investigations a good deal of information about members of most of the groups of invertebrate animals has been obtained, and the following statements may be regarded as a sample of the results.

RATE OF GROWTH IN SOME CŒLENTERATA.

Among the Cœlenterata it has been found that various species of Obelia and *Clytia Johnstoni* give off medusæ when not more than a month old. Similarly, *Bougainvillea ramosa* yielded medusæ at once when collected at an age of not more than six weeks and a few days. In all these cases, however, the observations do not cover the whole life-cycle as do the following. The commonest species of Tubularia—almost certainly *T. larynx*—has been found to give off actinulæ larvæ at an age of not more than six weeks, and in one experiment this species had moderately developed gonophores at an age of not more than 26 days. As these Tubularia actinulæ have been found to settle and grow into little polyps within a few days, it follows that this species may pass through its life-cycle within about six weeks and probably actually within four or five under favourable conditions. In the same way Plumularia and Gonothyræa have been found to give off planulæ at an age of not more than three months; thus, as these planulæ may probably settle almost immediately, these hydroids may complete their life-cycle within at least three months, and in both cases in a period probably less than that stated by some few weeks. Hence there can be little doubt that these hydroids pass through several generations—probably three and possibly more—in a year. A species of Syncoryne yielded medusæ at a maximum age of ten weeks, but doubtless the actual age was much less than this.

In all these cases, however, there can be little doubt that the rate of growth—probably apart from the question of food-supply—varies at different times of the year. So far as the investigations have been examined, it would appear that in this group most of the species mentioned above appear to have a maximum rate of growth in the months of August and September.

The most interesting record of the rate of growth obtained so far in Actinians is that of *Sagartia viduata*, which has been found to attain to full size at a maximum age of 14 to 15 months.

RATE OF GROWTH IN SOME PORIFERA AND THE LIFE-HISTORY OF SYCON, GRANTIA, AND LEUCOSOLENIA.

Among Porifera a fairly complete investigation of the life-history and rate of growth of *Sycon coronatum*, *Grantia compressa*, and a species of Leucosolenia has been made. These sponges have been found to be annuals, as they have generally been believed to be. But the interesting fact has been ascertained that there are two breeding seasons, especially well marked in *S. coronatum* and Leucosolenia, one in summer and one in late autumn. Data have, moreover, been obtained supporting the view that the same specimens may breed twice in their life-history, namely, once in late autumn and again in the following summer. Thus, therefore, it would seem that temperature is the main factor governing reproduction in these animals, since continuous rapid growth takes place in the winter, as will be seen from the following observations. Some very fine specimens of *S. coronatum* of known age have been obtained. One exceptionally fine specimen attained a length of more than 28 cms. with an average width of about 2·2 cms. in not more than 10 months 19 days, and growing during the period from July to May. Another specimen 24·8 cms. long grew between June and January in a period not longer than 7 months and 20 days. In another case several specimens measuring between 14 and 16 cms. long grew between May and January in a period not longer than 8 months and one day. It is an interesting fact that none of these specimens yielded embryos when they were isolated in dishes of sea-water, whereas tiny specimens from 3 to about 5 cms. taken in September and October gave off a good number of embryos. These tiny specimens have been obtained from several independent experiments started in early and late spring and in the summer, hence they are the sponges derived from the embryos liberated at the summer breeding period, namely, about the latter end of May or early June. The approximate age of these specimens is therefore about four months ; in one case the actual age of such specimens was not more than 15 weeks. It is highly probable, moreover, that these autumn breeding forms continue to grow through the winter and again give off embryos in the following summer, when they die down. However this may be, there can be no doubt that there are at least two broods of embryos produced in a year, and from the fact that specimens only 1·5 cms. long have been found to contain fully developed free embryos in the inner flagellated chambers in the autumn I think it very probable that this species might in favourable seasons yield three generations within a year, rushing through two of them in late autumn.

Similar breeding phenomena to those described in *S. coronatum* are presented by *G. compressa* and Leucosolenia. Tiny specimens of *G. compressa* 1·3 cms. long taken in October at an age not greater than 7 months and of an actual age of less than 4 or 5 months have been found to be crammed full of embryos, while large specimens 8 cms. long with an average width of 3·5 cms. taken in March and April have been found to contain only immature ova. In the following June, however, specimens similar to the latter have yielded crowds of embryos. Corresponding results to these have been obtained with Leucosolenia. Thus the summer and winter breeding periods appear to be general in our calcareous sponges. The life-cycle of Grantia has been carefully followed round the year, and it was observed that in one situation where this sponge was extremely common of a large size in June they gradually disintegrated during July, so that by August it was impossible to find any but the tiniest specimens, which were doubtless the first comers of the new summer crop. The same difficulty in finding any but small specimens was also met with on other grounds in the district where these sponges can generally be obtained at any other time of the year.

The summer crop continues to grow during the autumn, and by about December may attain to an area in side view, i.e. on one flat side, of about 10 sq. cms. By the following March specimens may be found with an area of from 25 to 30 sq. cms.,* and at the end of a year's growth in the following June specimens of average size may attain to an area of at least 30 sq. cms.* in side view, or in other words, the whole "body-wall" would have an area of more than 60 sq. cms. After delivering their summer embryos these specimens, as we have already seen, die down and a fresh crop arises.

Of siliceous sponges few records of much value have so far been obtained, but a colony of *Halichondria panicea* grew on a flat surface between June and the following January to an area of about 45 sq. cms. and of about the usual thickness of this sponge.

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* More exact measurements will be given later.

RATE OF GROWTH IN SOME PLATYHELMINTHES.

Among the Platyhelmia strong indications have been obtained that Cycloporus, Leptoplana, and their allies pass through a generation within a few months, but no certain evidence has been obtained with regard to these animals. The results will be more fully discussed later.

RATE OF GROWTH IN SOME ANNELIDA.

A good deal of information has been obtained of various members of the Annelid group, and especially of the sedentary Polychætes. *Pomatoceros trigueter* and *Hydroides norvegica* grow to nearly full size in about 4 months, and at this age the former has yielded in many cases practically 100 per cent of embryos on being artificially fertilized, while a specimen of Hydroides of the same age shed ripe eggs, but unfortunately no male of the same age was available for a fertilization. The common species of Filograna has been obtained, carrying ripe eggs and trochospheres at an age probably less than four months, having grown through the summer. About the same time another experiment yielded specimens with fully developed eggs at an age not greater than 10 weeks and 4 days. Later in the year full-sized specimens with buds had an age not greater than 4 weeks and 2 days. There can be little doubt, therefore, that in this species there is an alternation of generations, the summer forms producing eggs and sperm and the autumn and winter ones producing buds.

Polymnia, Dasychone, and many others have been found to attain a good size in much less than a year. Ripe *Serpula vermicularis* not more than about 10 months old yielded an excellent result on being fertilized. Dinophilus has been reared through at least one generation in the Laboratory within a period of 7 weeks, and Ophryotrocha to a medium size in 8 weeks, but with more attention doubtless the rate of growth in these two forms might easily be found to be twice as great. Chætopterus at an age less than 13 months grew a tube 14 cms. long and had developing ova in its gonad, and *Sabella pavonina* a tube 12·6 cms. long in less than 31 weeks, and at this age contained well-developed but not quite mature ova. Similar results have been obtained with many free-living Polychætes, but these will be discussed later.

RATE OF GROWTH IN SOME POLYZOA.

One interesting result has been obtained among the Polyzoa. By continued experiments and observations *Bugula flabellata** was found to grow to a good-sized colony and give off larvæ within a period of not more than 8 weeks. From the observations made there is no doubt that this species passes through several generations during the summer and autumn, and indications were given that the most rapid growth occurs during August and September. In one case more than 100 zooids were counted in a colony not more than a fortnight old. Another species of Bugula has been found to grow colonies 4 cms. high and 2·5 cms. wide in 15 weeks. Very large colonies of a Bowerbankia species of an age not more than 9 months gave off a great number of larvæ, and in another experiment a colony 4·5 cms. high and 2·5 cms. wide was obtained at an age not greater than 15 weeks. *Scrupocellaria reptans* formed good-sized colonies in less than 7 months ; *Membranipora membranacea* grew to a circular colony 6 cms. in diameter within 12 weeks, *Lepralia pallasiana* circular colonies 1·1 cms. in diameter within 8 weeks, and 3·1 cms. in diameter within 23 weeks. *Cellularia neritina* grows into huge colonies in the inner basin at the Great Western Docks in a year.

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* Including *Bugula calathus*, Norman, for the purpose of the present paper.

RATE OF GROWTH IN SOME CRUSTACEA.

A few observations have been made on members of the Crustacea, mostly of the sedentary forms.

Balanus balanoides attains to full size in a year and gives off large numbers of nauplii at this age, but there does not appear to be more than one breeding season, namely, in the late winter months. Other species of Balanus, however, have been found to grow to a large size in less than a year. Especially interesting results have been obtained in this group by examining the bottoms of ships in dry dock and obtaining information from the captain of the ship as to when the ship was last scraped and painted. From the information obtained in this way it has been found from independent data that *Conchoderma virgata* grows to a good size and gives off nauplii within from 4 to 5 summer months, and *Lepas anatifera* and *L. hilli* within the same period. *Conchoderma aurita* grows to a large size, namely, 7 cms. long, within 5 months, but was not found with embryos or nauplii when examined. This rapid growth of Cirripedes is well known to some captains of sailing vessels, who are constantly sailing the high seas in relatively slow-moving boats, for there is apparently a limit to the speed of the boat on which Lepas and Conchoderma will grow. The vessel on which the specimens mentioned above were obtained had travelled mostly at 6 to 8 knots I was told, hence the limit of speed for their growth must be something greater than this.

In this group a special experiment has been tried with success, with the object of entrapping young forms in a wire basket of a small mesh inside which, as the animals grow, they become imprisoned. Food is obtained by the animals from the natural growth on the wire basket and the surrounding parts. The wire basket was placed in a large floating wooden raft in Cawsand Bay adjacent to Plymouth Sound. From this cage put out in the sea on the 28th May, 1913, and taken in on 26th February, 1914, were obtained *Palæmon serratus* measuring on the average about 5·6 cms. long from the tip of the rostrum to the end of the tail, and two *Portunus puber*, one a male with a carapace width of 3·5 cms. and one female whose carapace measured 3·3 cms. wide. As the greatest width of the mesh of the wire cage at the close of the experiment was 14·5 mms., by 9 mms., it follows that the specimens of Portunus were in all probability samples of the young for the season of 1913, since the breeding season of this species of Portunus falls in about the spring of the year. (See "Plymouth Marine Invertebrate Fauna," p. 257, *J.M.B.A.*, N.S., Vol. VII, No. 2, 1904.) It is highly probable that the specimens of *Palæmon serratus* entrapped in the cage were also examples of last year's crop of this species, and as specimens about the size they attained occur in berry there would appear to be little doubt that this species becomes mature and bears young within a year. Some specimens are being kept alive in the tanks with a view to watching their subsequent growth.

An experiment conducted on similar lines on the Essex coast (see pp. 320 and 322) with a wire cage, the *greatest* width of any mesh of which at the end of the experiment was less than 2 cms., yielded four specimens of *Carcinus mænas*, three males and one female. The width of the carapace of the three males was respectively 3·6, 3·4, and 3·2 cms., and that of the female 3·1 cms. This experiment extended over a period of 15 weeks between the 18th June and the 3rd October. Hence there can be little doubt that the common crab also attains to maturity within a year. Further experiments will be made with cages of wire having a smaller mesh in the hope of following the rate of growth more fully in these and other species of Crustacea.

RATE OF GROWTH IN SOME MOLLUSCA.

In the Mollusca group the age at which several species begin to breed has been determined. The common mussel, *Mytilus edulis*, has been found to spawn naturally at an age of one year. From eggs spawned in this way a fertilization made by adding sperm from a male of the same age yielded 100 per cent of fertilized eggs. At this age the commonest sizes are from 3·5 to rather more than 4 cms. A good deal of material of this species has been obtained continuously during a period of two years, so that it will be possible to work out the rate of growth in this important mollusc fairly thoroughly. From several independent experiments it has been found that *M. edulis* may grow in this district to a size of from 3·5 to 4 cms. within the period between April and November, i.e. in about 30 weeks. During the winter it would appear that relatively little growth takes place. By the following April, however, specimens may attain to the size of upwards to 5 cms., and at the end of the summer following that in which the animals were spawned, i.e. at an age of about 18 months, the average length of specimens is about 5 cms. with a corresponding increase in width and depth, while one specimen of this age attained a length of 6·8 cms. and a width of 3·4 cms. The variations in size at different ages will be given later. An interesting comparison has been made between mussels 3·5 cms. long and about 10 months old and thick-shelled mussels from 1·3 to 1·6 cms. long from the exposed shore at Whitsand Bay. The latter were quite ripe and gave good fertilizations, whereas at the same time the former were not ripe. Thus it would seem that the Whitsand Bay specimens really were dwarfed individuals of an age of at least two years.

Continuous observations have also been made on the rate of growth in a few individuals of the common limpet, *Patella vulgata*. It has been found that specimens may attain a size of 4 cms. in less than 15 months, and at this age are ripe. An artificial fertilization made from these specimens gave ultimately a fair percentage of trochospheres. During 31 weeks between the 27th January and the 2nd September, 1913, two specimens grew on a flat surface, respectively, from (*a*) 2·1 cms. long by 1·6 cms. wide to 4·1 cms. long by 3·3 cms. wide, and (*b*) 3·8 cms. long by 3·2 cms. wide to 5·3 cms. long to 4·5 cms. wide. Thus the smaller specimen increased 2 cms. in length and the other 1·5 cms. in length. The age of the latter specimen when 5·3 cms. long was not more than two years. Another specimen grew between April 4th and September 2nd in the same year from 2·25 cms. long by 1·7 cms. wide to 3·3 cms. long by 2·85 cms. wide, thus increasing in length 1 cm. within 20 weeks. Thus the rate of growth of *P. vulgata* in this district is much greater—as indeed might be expected—than that found by Russell* in Scotland. These observations are, however, being continued, and the results in relation to those obtained by Russell will be discussed later when more data are available.

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* E. S. Russell, "The Growth of the Shell of *Patella vulgata*," *Proc. Zool. Soc.*, 1909, p. 235, I.

Anomia aculeata has in several independent experiments been found to attain to an average size for this species and to give larvæ on being fertilized at an age of less than four months. Specimens of this age have been taken at various times of the year with the same result, hence this species undoubtedly passes through two and probably three generations within a year. Next to the common mussel this is probably the commonest mollusc on our shores.

The boring mollusc, *Teredo navalis*, has been found to grow to a length of 19·8 cms. in 31 weeks, and made borings in soft wood 28 cms. long with an average width of about 1 cm. It was also found that the gill was alive in specimens obtained a fortnight after the wood in which they were living was taken out of the sea. Thus these animals would be able to live easily during the period during which most vessels would be in dry dock for scraping and painting, hence, as is well known but not always fully realized, it is highly important that wooden vessels should be constantly cleaned to prevent the attacks of this destructive mollusc.

THE RATE OF GROWTH OF *CREPIDULA FORNICATA.*

By means of a grant from the Royal Society a number of special experiments were carried out during the year of 1913 off the Essex coast with the object of determining the rate of growth in Crepidula. For this purpose a floating raft containing shells and tiles was moored at the mouth of the River Blackwater in the expectation of catching the spat. In putting out the raft and taking it in again in the autumn the Directors of the Tollesbury and West Mersea Oyster Company very kindly placed at my service the valuable help of their fishermen and their boats, and I wish here to express my thanks to them for the facilities they gave me in carrying out the experiment. The design of the experiment succeeded, and Crepidula spat was obtained on the raft and on the material placed in the raft, but unfortunately this success was marred by the fact that the raft had probably been touching the bottom of the river a few days when I went to examine it. It is therefore possible but not probable that some of the spat obtained on the raft may have crept on to it. Hence it is hoped to try the experiment again this year. From the position of some of the spat on the raft and on the tiles in it there was no doubt that they had been settled there some time, and therefore before the raft touched the bottom, and as the specimens obtained were all of sizes similar to the smallest sizes obtainable on the grounds in the district, and, further, since the size of the spat is what might be expected from the following experiment and other observations, there can be little doubt that they had settled on the raft and had grown in position, and are therefore examples of the spat for that season. The spat obtained varied in length from 4·5 mms. to 14 mms., and altogether 15 specimens were obtained. Their average length was 8·1 mms. and their average breadth 6·4 mms. Since they had grown during the time the raft was in the sea, namely, from June 16th to October 2nd, their greatest possible age is 15 weeks.

At the same time as the experiment described above was begun another experiment suggested by Mr. J. Bean, of West Mersea, was started for the purpose of observing the rate of growth in the sea of young specimens which were considered almost certainly a year old. For this experiment Mr. Bean very kindly gave me the use of two of his oyster trays—which are shallow wooden trays with one side covered with perforated zinc and the other with small-meshed wire-netting—and also provided new wooden posts, which are driven into the mud to carry the trays. The trays were filled with shells and tiles secured to one side of the tray and a number of young Crepidula were put on to the shells. A few older specimens were marked and the shells on which they were sitting secured to the tray. The total number of young specimens put in the tray was 131, and their average length 10·7 mms. They varied in size from 5 to 15 mms., but the commonest sizes were about 9 to 12 mms. These young ones were put in the trays on June 18th and examined again on the 3rd of the following October. When examined at the latter date a number of them were found dead in the bottom of the tray and only 28 could be found alive. These remaining specimens varied in length from 1·4 cms. to 2·65 cms., and their average length was 2·1 cms., but 17 of them were more than 2 cms. long. It is quite clear, however, that within the period of the experiment, namely, 15 summer weeks, Crepidulas about 1 cm. long grow to a length of two centimetres. Hence the spat obtained in the former experiment may be regarded as a fair sample of the spat for the season of 1913. Thus during the summer Crepidula spat grows to a size of about a centimetre and appears to grow little during the winter, as indeed was found by examining batches of the tiniest specimens procurable on the grounds in the autumn and in the following late winter. During the next summer the young slipper-limpets may grow to a length of about an inch. This experiment is being continued and it is hoped to follow the rate of growth further. Of the few larger marked Crepidula put in this tray only two specimens showed an increase in size. One specimen grew from a length of 25 mms. and a width of 17 mms. to a length of 29 mms. and a width of 20·5 mms.; the other one grew from a length of 28 mms. and a width of 13 mms. to a length of 33·5 mms. and a width of 26 mms. It is thus seen that *C. fornicata* may grow to a length of at least 3 cms. within 2½ years, but it is desirable that the rate of growth should be observed in a larger number of individuals than was possible under the conditions of these experiments.

THE AGE OF SEX-CHANGE IN *CREPIDULA FORNICATA.*

In the tray experiment just described it was found that some of the small Crepidula had formed chains of two individuals, and in one case two specimens had put themselves in chain with one of the larger marked Crepidula to form a chain of three. When measuring these slipper-limpets their sex condition was also recorded and the singular fact established that while the individuals in chain were quite vigorous males, those which were leading a solitary life were changing from males into females. This phenomenon had indeed been suspected from the extensive examinations which have been made from time to time during the last few years on batches of Crepidula. The condition of these small Crepidulas may be gathered from the following records in which the abbreviations used in an earlier paper* are again adopted. The solitary specimens were recorded as follows: 8 specimens ♂ p.sm.; 3 ♂ p.tr.; one p.r.ut.r.; 2 ♀ ut.sm.p.tr.; 4 or 5 ♂. In the chains formed by the small specimens (one year old forms) the sexes were recorded as follows: (1) A ♀ p.r., B ♂; (2) A ♀ ut.r.? p.r., B ♂. The chains formed by the small specimens with the larger marked specimens, which in all cases are the A's in the chain, were recorded as follows: A I sex not recorded, B ♂, C ♂; A II ♀ p.tr., B ♂; A IV ♀ p.tr., B ♂. Thus in all cases where the young Crepidula had formed chains they retained their characters as males, whilst 14 out of 19 that remained solitary had begun to change their sex. Thus the absence of association with their fellows in chains undoubtedly results in a more rapid change from the male condition to the female condition than in the cases where the Crepidulas are able to form chains. Sex-change in Crepidula therefore may take place in the second year of the life of isolated individuals.

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* J. H. Orton, "On the Occurrence of Protandric Hermaphroditism in *Crepidula fornicata*," *Proc. Roy. Soc. B.*, Vol. 81, 1909.

The meaning of the abbreviations used above is as follows:—

p.sm. = penis small; p.tr. = trace of penis; p.r. = penis rudimentary.

ut.sm. = uterus small; ut.r. = uterus rudimentary.

THE RATE OF GROWTH OF OYSTER SPAT IN THE FIRST SUMMER.

Besides the two experiments described above two other independent ones were carried out, but without success, for the purpose of catching Crepidula spat. These experiments, however, were successful in catching a large amount of oyster spat and other marine invertebrates, and in one case a few spat of the common cockle, *Cardium edule,* which are of much interest, were obtained. Measurements of the oyster spat have been made and a growth curve will be given to show the variation in size in spat of all ages up to 10 and 15 weeks. The limits of size of the 10-weeks' spat—as determined by the area of one valve—are from about 2 sq. mms. to 175 sq. mms., and the commonest size appears to be about 75 sq. mms. The largest specimens of 15-week spat have an area of about 250 sq. mms., i.e. about a square inch. Samples of these oysters are still being kept under observation with the object of observing their subsequent rate of growth and the age at which they begin to spawn.

The spat of the *C. edule* mentioned above varied in their greatest breadth between 2·4 mms. and 8·4 mms. and their greatest age is 15 weeks. Other observations on this mollusc, however, are being carried out with the object of following more fully the rate of growth, and particulars will be given later.

A large collection of various molluscs has also been made with a view to investigating their age from the periodicity of the main lines of growth. Some success has already been obtained with *Patella vulgata*, *C. fornicata*, *C. edule,* and the fresh-water mussel, *Anodonta cygnea*, in all of which the periodicity of growth is well marked. In all these cases, however, it is important to establish the rate of growth during the first season, and, as has already been noted above, valuable information in this respect has been obtained for Crepidula, Patella, Mytilus, Cardium, and Ostrea.

THE LIFE-HISTORY OF *GALVINA PICTA*.

Some remarkable facts relating to the life-history of the Nudibranch Molluscs have been obtained, and the following case may be taken as an example. The raft moored in Cawsand Bay—mentioned above—was visited six weeks after it was put out in the sea. It was found to be covered with a large scattered growth of the hydroid *Obelia geniculata*, on which the adult Nudibranchs, *Galvina picta*, *G. exigua*, *Tergipes despectus*, *G. farrani*, and young *Facelina drummondi* and *Doto coronata* were feeding.

G. picta was the dominant Nudibranch, and 53 specimens were brought in and measured. Their average length from tip of head to end of tail was 11 mms., and they varied in length from 7 to 17 mms. Masses of spawn of both *G. picta* and *exigua* were present on the hydroids, and from these masses free-swimming veligers were being given off. Thus these Nudibranchs had undoubtedly peopled the raft as veligers, rushed through their development at the expense of the hydroid, and were giving off veligers again to populate hydroids elsewhere within a period not longer than 6 weeks and 2 days. Such a rapid growth is very probably a necessity for hydroid-feeding organisms, since the hydroids themselves attain maturity very quickly. In this respect it is also of great importance to the race that some Nudibranchs are protandric hermaphrodites,* for by this means a few individuals are able to multiply rapidly where food is abundant, and thus the race by means of its free-swimming larvæ is frequently able to utilize an abundant food-supply wherever such is available.

THE LIFE-HISTORY OF CIONA, CLAVELLINA, AND ASCIDIELLA.

In the group of Tunicata the rate of growth in many species has been thoroughly worked out. *Ciona intestinalis*, *Ascidiella aspersa*, *Molgula ampulloides ?* have all been found to be ripe and yield embryos on being artificially fertilized at an age of not more than 3½ months, and in some cases have themselves extruded fertilized eggs. Better fertilizations of these forms are, however, obtained from specimens about 4¼ months old. At an age of less than 15 weeks *Ascidia conchilega* from the Essex coast also gave 100 per cent of tadpoles on being artificially fertilized. Large numbers of successful artificial fertilizations were made in this group in running down the minimum age at which tadpoles can be obtained, and it was generally noticed that cross-fertilizations gave better results than self-fertilizations. All these species, however, grow at a much greater rate in the summer and autumn than at any other time of the year, and in the months of August and September *Clavellina lepadiformis* and *Leptoclinum* (*Diplosoma*) *gelatinosum* grew from the tadpole to a tadpole-bearing adult within 8 weeks. In one remarkable case *L. gelatinosum* was found to have raced through the whole life-cycle from the tadpole to an adult form giving off tadpoles at an age not greater than 3 weeks and 5 days. And indeed about this time of the year, August, this compound Ascidian is to be found overgrowing almost everything, both about and below low-water mark.

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* As has been found by the writer in researches in this group.

The life-history of *C. intestinalis* is very similar to that of the Sycons described above. It has been definitely established that the species dies down about October, at about which time very fine specimens upwards to a foot long can be obtained. This fact has, however, been known at this laboratory for several years. By the end of October it is difficult to find Ciona of even medium size, but very small specimens are not uncommon. Breeding commences again after the winter season about April, and from April to October specimens may attain to a length of 15 cms., while those which have wintered and are practically a year old at this time have been found to attain a length of 30 cms. It is thus evident that Ciona is an annual, but passes through at least two generations in a year, and in favourable seasons may yield three, rushing through two generations in the autumn, as in the case of the Sycons. Thus these observations support the statement made by Anton Dohrn that Ciona at Naples passes through three generations in a year. (See footnote, p. 326.) The life-history of *C. lepadiformis* has been found to be very similar to that of *C. intestinalis.* It appears in this district about the end of April—apparently growing from dormant stolons —and grows to huge colonies during the summer, and at the same time passes through at least two generations. At about October these colonies die down and nothing is to be seen of them during the winter until about the following April.

A. aspersa has a somewhat similar life-history, but does not die down as completely in the autumn as Ciona. Between April and September this species has been found to grow to a length of 9 cms., very nearly the maximum size. *M. ampulloides?* has also a very similar life-history to that of Ascidiella, and gives quite good fertilizations at an age of 3 months, and this sub-spherical Ascidian may attain at this age a diameter of 2·5 cms., a size not far from the maximum for this species.*

RATE OF GROWTH IN SOME OTHER TUNICATES.

Botryllus violaceus gives off larvæ at an age not greater than 3 months and grows to large colonies during the summer. Thus in the case of all these Ascidians there are at least two crops of larvæ produced in a year, and in some of them, as in Leptoclinum, Clavellina, and Botryllus, there may be three or more crops in favourable seasons.

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* Development in this species is remarkably rapid; the fertilized egg developing into a metamorphosing larva in less than 24 hours.

It is interesting that the maximum rate of growth in this group occurs at about the same time of the year as that found in the Sycons, some Polyzoa, some Molluscs, and some Hydroids. This period of maximum rate of growth occurs about August and September, and it is hoped that when the whole of the material collected has been worked out that it will be possible to estimate more accurately the rate of growth for different times of the year in all the groups.

RATE OF GROWTH IN *SACCORHIZA BULBOSA*.

A few marine algæ have been collected in the course of the experiments, and so far the most interesting growth obtained is that of *Saccorhiza* (*Laminaria*) *bulbosa*, which between April and October, a period of 7 months, was found to grow a lamina 3 to 5 feet long and a sub-spherical base about 5 inches in diameter.

SUMMARY.

From the foregoing preliminary account it will have been seen that the rate of growth and the period of the life-cycle in marine invertebrates are in many cases much more rapid than has hitherto been suspected. Many forms which have been generally considered annuals with one breeding period, such as the Sycons and other Porifera, some Polyzoa, some Ascidians, some Molluscs and some Annelids, have been shown to pass through two generations, and in many cases there are strong probabilities that they may pass through more than two generations in a year. Even among the Hydroids the rate of growth is probably greater than has generally been suspected.

The results obtained will be discussed in relation to those obtained elsewhere, when the whole of the scattered literature on this subject has been gathered together. So far, however, very few reliable observations have been found on the rate of growth in marine invertebrates, as indeed Weismann* has already noticed, and I should be very glad to receive any references to work of this kind that readers may have come across.

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* A. Weismann, *Essays upon Heredity*, Vol. 1, p. 57. Edited by E. B. Poulton, S. Schönland, and A. E. Shipley. Oxford, 1891

General Report on the Larval and Post-Larval Teleosteans in Plymouth Waters.

By

R. S. Clark, M.A., B.Sc.,

Naturalist to the Association, Plymouth Laboratory.

With 11 Figures in the Text.

CONTENTS.

PAGE
INTRODUCTION 327
CHART . . . . facing page 329
TABLE I. LIST OF STATIONS 329
LIST OF FAMILIES REPRESENTED—
Clupeidæ 338
Syngnathidæ 340
Ammodytidæ 340
Gadidæ 340
Mullidæ 346
Labridæ 347
Carangidæ 348
Scombridæ 349
Zeidæ 350
Caproidæ 353
Pleuronectidæ 355
Gobiidæ 372
Cottidæ 375
Cyclopteridæ 376
Triglidæ 376
Trachinidæ 377
Callionymidæ 378
Gobiesocidæ 378
Blenniidæ 379
TABLE XXV. GENERAL TABLE 380
CONCLUDING REMARKS 392
LITERATURE 392

INTRODUCTION.

THE material on which the present report is based was collected by the *Oithona* from 1906 to 1909 inclusive, and during the latter half of 1913. Attention was directed particularly to the capture and determination of the post-larval fishes. The investigations during the first four years were carried out by Mr. A. E. Hefford, and his notes have been fully relied upon for the identification of the species. For the collecting and working out of the 1913 material I am directly and wholly responsible.

The young-fish trawl was used throughout for the capture of the specimens, and hauls were taken at depths ranging from the surface to the bottom. This method of securing the young pelagic stages has proved so successful in the Danish researches that it has been followed at Plymouth, with equally good results.

All the nets used were constructed on the system of the Petersen young-fish trawl, and three qualities of material were used. These were coarse sacking (" Stramin "), with mesh $\frac{1}{16}''$ square ; cheesecloth, with mesh $\frac{1}{32}''$ square ; and mosquito netting. In order to withstand the strain of pulling on board, the last type was strengthened by an outer herring-net. It was noticeable that every sample taken with the first two types contained a mass of stringy substance, indicating considerable wear and tear of the net. As a result, these nets became weakened and quickly broken up, especially near the cod end.

Table 1 gives a record of the number of hauls with the locality, date, and depth at which these were taken. To distinguish between the hauls taken by Mr. Hefford and those by myself, I have used the letters H and A respectively, which appear after the number of the haul. Letters corresponding to the chart areas are also represented.

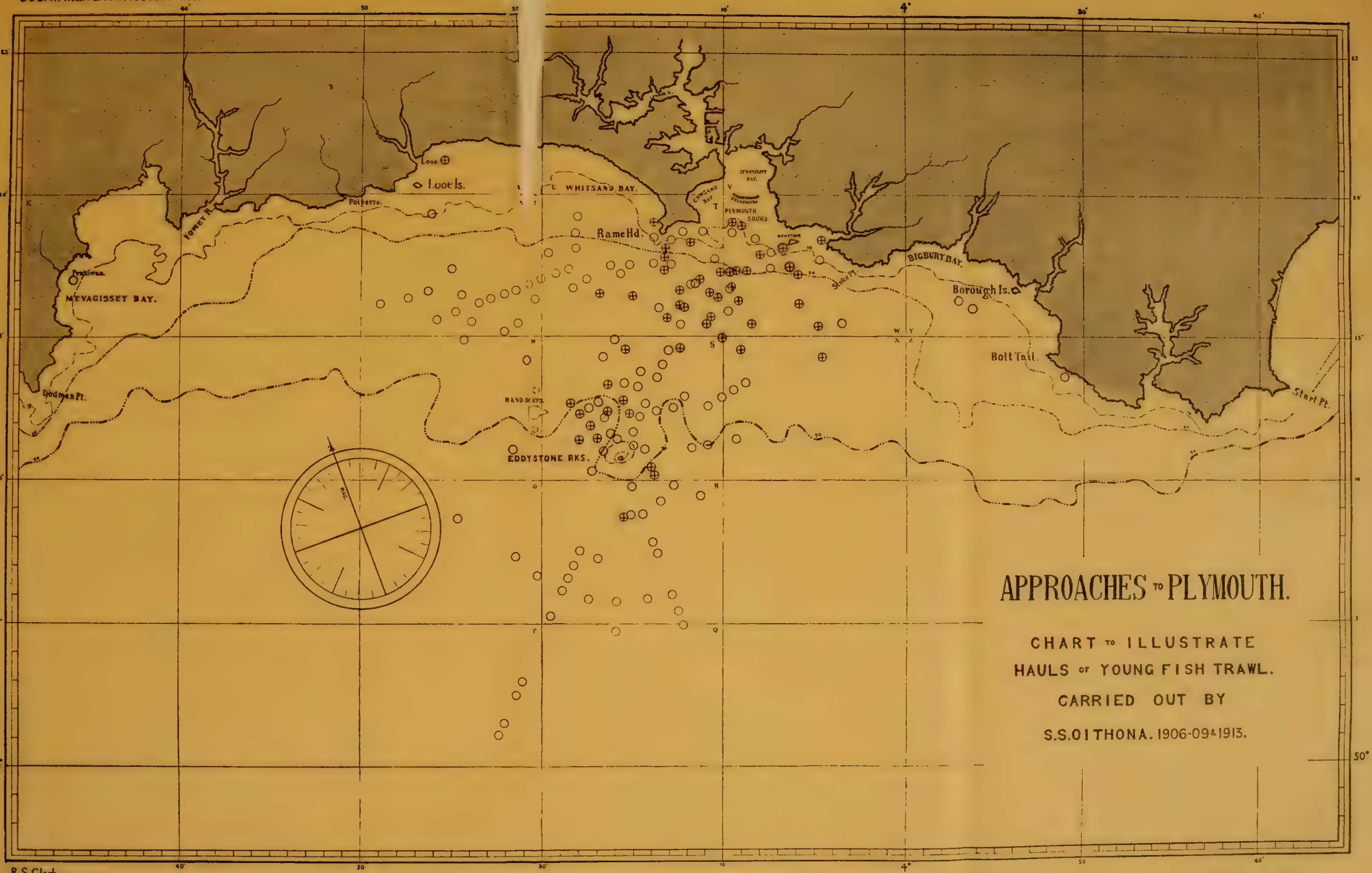
Tables 2–24 contain records of the number and size of the individuals of each species investigated, and these are usually accompanied by short notes on the more important biological features of the particular groups, but it has been necessary to give a detailed description of a few forms which appear to be either entirely new, or at most, little known.

Table 25 summarizes the captures of the species the individuals of which were too numerous for separate tabulation.

The region investigated and shown on the accompanying chart has been subdivided into areas with latitude of 5′ and longitude of 10′. An approximation to the positions of the hauls can thus be arrived at by reference to Table 1. Small crossed circles have been used to indicate the position of the hauls for the years 1906–1909 and plain circles for 1913.

The credit of the work for the results from 1906–1909 must be given to Mr. A. E. Hefford, while I have received much helpful advice from Dr. Allen, Mr. C. Tate Regan, Dr. Kyle and Mr. E. T. Browne. In the preparation of this report I have had the assistance of my colleague Mr. E. Ford, to whom I am also greatly indebted for the excellent series of drawings which are reproduced in the text and for the lettering in the chart. Further, Mr. Gossen has been a valuable help in the collecting and sorting out of the material.

Journ. Mar. Biol. Assoc. Vol. X.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K
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U
WHITSAND BAY.
Rame Hd.
CAWSAND BAY
T
V
JENNYCLIFF BAY.
BREAKWATER
PLYMOUTH SOUND
NEWSTONE
Stoke Pt.
BIGBURY BAY.
Borough Is.
W
Y
X
Z
Bolt Tail.
Start Pt.
N
S
HAND DEEPS.
EDDYSTONE RKS.
O
R
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Q
MAG.

APPROACHES TO PLYMOUTH.

CHART TO ILLUSTRATE
HAULS OF YOUNG FISH TRAWL.
CARRIED OUT BY
S.S. OITHONA. 1906-09 & 1913.

R. S. Clark.

To face p. 329.

TABLE I. LIST OF STATIONS.

Explanation of abbreviations. S. = surface. M. = midwater. B. = bottom. M.H. = midnight haul.

No. of Haul.		Date.	Depth of Capture.	Duration of Haul in min.	Locality.	Total Depth in fms.	Chart Area.
I.	H	10.v.06	B.	—	Cawsand Bay	<10	T.U.
II.	H	22.v.06	S.	15	Mewstone E. by N. ½ N., Rame Hd. N.W. by N.	24	W.
III.	H	,,	M.	30	,, E. about 1 mile	15	W.
IV.	H	,,	B.	30	,, E. by N. ½ N., Rame Hd. N.N.W.	25	T.
V.	H	,,	B.	—	Cawsand Bay	<10	T.U.
VI.	H	30.v.06	B.	25	Rame Hd. N.E. ½ N., Eddystone S.S.W.	28	S.
VII.	H	,,	S.	30	Whitsand Bay, Rame Hd. S. ½ E. half a mile	<10	T.
VIII.	H	,,	B.	30	,, ,, ,, ,,	<10	T.
IX.	H	20.vi.06	S.	30	Mewstone Buoy E. 1 mile	15	W.
X.	H	,,	M.	30	,, ,, ,,	15	W.
XI.	H	,,	B.	15	,, ,, ,,	15	W.
XII.	H	,,	S.	15	Mewstone E.N.E. 4 miles, Rame Hd. N. by W.	27	T.
XIII.	H	,,	M.	—	,, ,, ,, ,,	27	T.
XIV.	H	,,	B.	15	,, ,, ,, ,,	27	T.
XV.	H	28.vi.06	S.	15	,, ,, ,, ,,	27	T.
XVI.	H	,,	M.	15	,, ,, ,, ,,	27	T.
XVII.	H	,,	B.	15	,, ,, ,, ,,	27	T.
XVIII.	H	,,	M.	20	Cawsand Bay	<10	T.U.
XIX.	H	20.vii.06	S.	—	Mewstone Buoy E. 1 mile	15	W.
XX.	H	,,	B.	—	Rame Hd. N. by W., Mewstone Buoy N.E. by E. 4 miles	28	S.X.
XXI.	H	27.vii.06	—	20	,, ,, ,, E.N.E. 4 miles	28	T.
XXII.	H	,,	—	20	Mewstone Buoy E. 1 mile	15	W.
XXIII.	H	10.ix.06	B.	—	Mewstone E. by N. 4 miles	24	T.
XXIV.	H	,,	M.	—	,, E. by N., Rame Hd. N. ¼ E.	27	T.
XXV.	H	11.ix.06	B.	—	Whitsand Bay	ca. 10	L.U.
XXVI.	H	17.ix.06	B.	—	Mewstone E.N.E. 4 miles, Rame Hd. N. ½ W.	27	T.
XXVII.	H	,,	M.	—	,, E. by N. 5 miles, Rame Hd. N.	26	T.
XXVIII.	H	21.ix.06	B.	20	Eddystone S.E. by S. ¼ S. 1 mile	31	S.
XXIX.	H	,,	—	—	,, S.S.E. 2½ miles	31	S.
XXX.	H	4.x.06	B.	25	Mewstone E. ½ N. 2 miles	21	W.
XXXI.	H	25.iii.07	S.	30	Eddystone S.W. by S. 1½ miles	29	S.
XXXII.	H	,,	M.	20	,, S.W. by S. ¼ S.	29	S.
XXXIII.	H	11.iv.07	M.	—	Mewstone E. by N. ½ N., Rame Hd. N.N.W. 2 miles	23	T.
XXXIV.	H	,,	B.	—	,, ,, ,, ,, 2½ miles	24	T.
XXXV.	H	6.vi.07	B.	—	,, E. ½ N., Penlee N. by W.	23	W.

TABLE I. LIST OF STATIONS.—*Continued.*

Explanation of abbreviations. S.=surface. M.=midwater. B.=bottom. M.H.=midnight haul.

No. of Haul.		Date.	Depth of Capture.	Duration of Haul in min.	Locality.	Total Depth in fms.	Chart Area.
XXXVI.	H	6.vi.07	B.	—	Cawsand Bay	<10	T.U.
XXXVII.	H	1.vii.07	S.	—	Mewstone N.E. by E., Rame Hd. N.W. by N. 3 miles	23	W.
XXXVIII.	H	,,	B.	—	,, ,, ,, ,, ,,	23	W.
XXXIX.	H	10.vii.07	B.	20	Rame Hd. N. by E. $\frac{1}{2}$ E., Eddystone S.W. by S.	24	T.
XL.	H	19.vii.07	B.	20	Mewstone E. $\frac{3}{4}$ N., Penlee Pt. N. $\frac{1}{2}$ W. 3 miles	24	W.
XLI.	H	26.v.08	?	20	Rame Hd. N.E. $2\frac{1}{4}$ miles	27	T.
XLII.	H	28.v.08	?	—	Rame-Eddystone	20–30	S.T.
XLIII.	H	,,	?	20	,, ,,	20–30	S.T.
XLIV.	H	,,	?	—	,, ,,	20–30	S.T.
XLV.	H	1.vi.08	S.	20	Rame Hd. N. by E. $\frac{3}{4}$ mile	24	T.
XLVI.	H	,,	M.	—	,, N. $\frac{1}{2}$ mile	20	T.
XLVII.	H	,,	B.	—	,, ,,	20	T.
XLVIII.	H	,,	S.	—	Eddystone S.S.E. $1\frac{1}{2}$ miles	31	S.
XLIX.	H	,,	M.	—	,, ,, 2 ,,	32	S.
L.	H	,,	B.	—	,, ,, $1\frac{1}{2}$,,	31	S.
LI.	H	4.vi.08	B.	—	Cawsand Bay	<10	T.U.
LII.	H	,,	?	—	,, ,,	<10	T.U.
LIII.	H	,,	S.	—	Mewstone Buoy	<10	W.
LIV.	H	,,	M.	—	,, ,,	<10	W.
LV.	H	5.vi.08	S.	—	Cawsand Bay	<10	T.U.
LVI.	H	,,	B.	—	,, ,,	<10	T.U.
LVII.	H	10.vi.08	S.	—	Mewstone Buoy N. by E. $\frac{3}{4}$ mile	20	W.
LVIII.	H	,,	B.	—	,, ,, ,, 2 miles	24	W.
LIX.	H	12.vi.08	S.	—	Rame Hd. N. $\frac{1}{2}$ E. $2\frac{1}{2}$ miles	27	T.
LX.	H	,,	B.	—	,, ,, ,,	27	T.
LXI.	H	15.vi.08	B.	—	Mewstone E. $2\frac{1}{2}$ miles	22	T.
LXII.	H	19.vi.08	S.	—	Cawsand Bay	<10	T.U.
LXIII.	H	,,	B.	—	,, ,,	<10	T.U.
LXIV.	H	,,	S.	—	Rame Hd. N. by E. 4 miles	27	S.
LXV.	H	,,	M.	—	,, ,, ,,	27	S.
LXVI.	H	,,	B.	—	,, ,, ,,	27	S.
LXVII.	H	,,	S.	—	Whitsand Bay	10–20	M.T.
LXVIII.	H	,,	B.	—	,, ,,	10–20	M.T.
LXIX.	H	23.vi.08	S.	—	Stoke Pt. N.E. $3\frac{1}{2}$ miles	25	X.
LXX.	H	,,	M.	—	,, ,, ,,	25	X.

LXXI.	H	23.vi.08	B.	—	Stoke Pt. N.E. 3½ miles	25	X.
LXXII.	H	,,	B.	—	Cawsand Bay	<10	T.U.
LXXIII.	H	25.vi.08	B.	—	Looe Is. W.S.W. 1¼ miles	15	M.
LXXIV.	H	30.vi.08	?	—	Rame Hd. N.E. 2¼ miles	27	T.
LXXV.	H	,,	B.	—	Cawsand Bay	<10	T.U.
LXXVI.	H	2.vii.08	M.	—	Mewstone E. by S. ¾ mile	12	W.
LXXVII.	H	,,	B.	—	,, ,, ,,	12	W.
LXXVIII.	H	15.vii.08	?	—	Cawsand Bay	<10	T.U.
LXXIX.	H	,,	?	—	Mewstone E. by N. 1¾ miles	ca. 18	W.
LXXX.	H	,,	?	—	,, ,, ,,	ca. 18	W.
LXXXI.	H	20.vii.08	M.	—	Eddystone S. by W. 2½ miles	30	S.
LXXXII.	H	,,	?	—	,, ,, ,,	30	S.
LXXXIII.	H	21.vii.08	M.	—	Mewstone Buoy N. by W. 1 mile	20	W.
LXXXIV.	H	30.vii.08	?	—	Eddystone N. by E. ½ E. 2 miles	35	R.
LXXXV.	H	,,	B.	—	,, ,, ,,	35	R.
LXXXVI.	H	6.viii.08	?	—	Mewstone N.E. 4 miles	27	X.
LXXXVII.	H	10.viii.08	S.	—	Breakwater N.N.E. 1 mile	<10	W.
LXXXVIII.	H	17.viii.08	S.	—	Mewstone N.E. 3 miles	26	W.
LXXXIX.	H	,,	B.	—	,, ,,	26	W.
XC.	H	,,	B.	—	Cawsand Bay	<10	T.U.
XCI.	H	20.viii.08	S.	—	Mewstone N. 3 miles	25	W.
XCII.	H	,,	B.	—	,, ,,	25	W.
XCIII.	H	26.viii.08	—	—	Cawsand Bay	<10	T.U.
XCIV.	H	,,	M.	—	,, ,,	<10	T.U.
XCV.	H	28.iv.09	S.	—	,, ,,	<10	T.U.
XCVI.	H	,,	B.	—	,, ,,	<10	T.U.
XCVII.	H	3.v.09	?	—	,, ,,	<10	T.U.
XCVIII.	H	7.v.09	?	—	Bovisand Bay	<10	W.
XCIX.	H	13.v.09	M.	—	Eddystone S.S.W. 2 miles	29	S.
C.	H	24.v.09	S.	—	Whitsand Bay	10-20	M.T.
CI.	H	,,	B.	—	,, ,,	10-20	M.T.
CII.	H	2.vi.09	S.	—	Rame Hd. N. 2 miles	26	T.
CIII.	H	,,	M.	—	,, ,,	26	T.
CIV.	H	,,	B.	—	,, ,,	26	T.
CV.	H	10.vi.09	S.	—	Whitsand Bay	10-20	M.T.
CVI.	H	,,	B.	—	,, ,,	10-20	M.T.
CVII.	H	22.vi.09	S.	—	Cawsand Bay	<10	T.U.
CVIII.	H	,,	B.	—	,, ,,	<10	T.U.
CIX.	H	25.vi.09	S.	—	,, ,,	<10	T.U.
CX.	H	,,	B.	—	,, ,,	<10	T.U.
CXI.	H	29.vi.09	S.	—	Eddystone N.W. by W. 1 mile	31	S.

TABLE I. LIST OF STATIONS.—*Continued.*

Explanation of abbreviations. S.=surface. M.=midwater. B.=bottom. M.H.=midnight haul.

No. of Haul.	Date.	Depth of Capture.	Duration of Haul in min.	Locality.	Total Depth in fms.	Chart Area.
CXII. H	29.vi.09	M.	—	Eddystone N.W. by W. 1 mile	31	S.
CXIII. H	,,	B.	—	,, ,, ,,	31	S.
CXIV. H	6.vii.09	S.	—	Cawsand Bay	<10	T.U.
CXV. H	,,	B.	—	,, ,,	<10	T.U.
CXVI. H	8.vii.09	—	—	Outside Breakwater	<10	W.
CXVII. H	13.vii.09	S.	—	Eddystone S.E. 1½ miles	32	S.
CXVIII. H	,,	M.	—	,, ,,	32	S.
CXIX. H	16.vii.09	S.	—	Mewstone E. by N. 1¾ miles	ca. 18	W.
CXX. H	20.vii.09	S.	—	Eddystone N.W. 1¼ miles M.H.	32	S.
CXXI. H	,,	?	—	,, ,, M.H.	32	S.
CXXII. H	,,	?	—	,, ,, M.H.	32	S.
CXXIII. H	6.viii.09	S.	—	Mewstone N.E. 4 miles	27	X.
CXXIV. H	,,	M.	—	,, ,,	27	X.
CXXV. H	,,	B.	—	,, ,,	27	X.
CXXVI. H	11.viii.09	S.	—	Breakwater N.E. 1 mile	<10	W.
CXXVII. H	19.viii.09	S.	—	Cawsand Bay	<10	T.U.
CXXVIII. H	,,	M.	—	,, ,,	<10	T.U.
CXXIX. H	26.viii.09	?	—	Eddystone S. ½ W. 1½ miles	31	S.
CXXX. H	,,	B.	—	,, ,,	31	S.
CXXXI. H	27.viii.09	M.	—	Rame Hd. E.N.E. 3 miles	26	T.
CXXXII. H	30.viii.09	M.	—	,, S.E. by E. 1 mile	11	T.
I. A	6.vi.13	S.	20	Off Pentewan Beach, Mevagissey Bay	<10	K.
II. A	,,	B.	20	,, ,, ,, ,,	<10	K.
III. A	11.vi.13	M.	20	Looe Is. N., Rame Hd. N.E. by E.	33	N.
IV. A	,,	S.	20	,, ,, ,,	33	N.
V. A	12.vi.13	M.	20	Looe N. ½ E., Rame E.	27	M.
VI. A	13.vi.13	M.	20	Cawsand Bay	<10	T.U.
VII. A	,,	S.	20	Off Penlee Pt.	11	T.
VIII. A	,,	M.	20	Between Penlee Pt. and Rame Hd.	<10	T.
IX. A	,,	B.	20	Whitsand Bay E.	10–20	T.U.
X. A	16.vi.13	B.	20	Between Penlee and Rame Hd.	<10	T.
XI. A	,,	B.	20	Eddystone N.W. 2 miles	32	R.
XII. A	18.vi.13	S.	20	Looe N.N.E. M.H.	ca. 25	M.
XIII. A	,,	M.	20	Eddystone S.E. by S. M.H.	ca. 27	N.
XIV. A	,,	B.	20	,, ,, M.H.	ca. 27	N.

XV.	A	18.vi.13	M.	20	Off Rame Hd.	10–20	T.
XVI.	A	19.vi.13	M.	20	Rame Hd. N.W. $\frac{1}{4}$ W. 2 miles	17	T.
XVII.	A	,,	M.	20	Mewstone N.E. by E. 1 mile	20	W.
XVIII.	A	,,	?	20	Cawsand Bay	<10	T.U.
XIX.	A	20.vi.13	M.	20	Between Mewstone and Stoke Pt.	10–20	W.
XX.	A	,,	S.	20	Eddystone $\frac{3}{4}$ mile W.	29	S.
XXI.	A	24.vi.13	S.	20	Rame E. by N. $6\frac{1}{2}$ miles	26	M.
XXII.	A	27.vi.13	M.	20	Rame E. $\frac{1}{2}$ N. 5 miles	27	M.
XXIII.	A	30.vi.13	B.	20	Looe Eddystone	20–30	M.
XXIV.	A	3.vii.13	M.	20	,, ,, Rame E.	20–30	M.
XXV.	A	7.vii.13	B.	20	Whitsand Bay E.	10–20	T.U.
XXVI.	A	8.vii.13	M.	20	Bigbury Bay	10–20	Y.
XXVII.	A	10.vii.13	S.	20	Cawsand Bay	<10	T.U.
XXVIII.	A	11.vii.13	M.	20	Looe Eddystone	20–30	M.
XXIX.	A	,,	S.	20	,, ,,	20–30	M.
XXX.	A	14.vii.13	M.	20	Whitsand Bay	10–20	M.T.
XXXI.	A	,,	S.	20	,, ,,	10–20	M.T.
XXXII.	A	15.vii.13	B.	20	Off Polperro	ca. 20	M.
XXXIII.	A	,,	S.	20	Off Looe	<10	L.M.
XXXIV.	A	16.vii.13	M.	20	Rame E. 5 miles	27	M.
XXXV.	A	17.vii.13	S.	20	White Patch to New Ground Buoy, Plymouth Sound	<10	V.
XXXVI.	A	18.vii.13	M.	20	Rame Hd. N. by W. $\frac{1}{2}$ W. 2 miles	23	T.
XXXVII.	A	24.vii.13	B.	20	Eddystone E.S.E.	ca. 30	S.
XXXVIII.	A	24.vii.13	M.	20	,, ,,	ca. 30	S.
XXXIX.	A	25.vii.13	S.	30	Rame N.E. by N. 1 mile	25	T.
XL.	A	28.vii.13	M.	20	Cawsand Bay	<10	T.
XLI.	A	,,	M.	20	Outside Breakwater	<10	W.
XLII.	A	,,	M.	20	Jennycliff Bay	<10	V.
XLIII.	A	,,	S.	20	,, ,,	<10	V.
XLIV.	A	29.vii.13	S.	20	Eddystone S. by W. $\frac{1}{2}$ mile	ca. 29	S.
XLV.	A	,,	B.	20	,, S.E. $\frac{1}{2}$ mile	ca. 25	S.
XLVI.	A	,,	M.	20	,, E. 1 mile	31	S.
XLVII.	A	30.vii.13	S.	20	Jennycliff Bay	<10	V.
XLVIII.	A	,,	B.	20	,, ,,	<10	V.
XLIX.	A	31.vii.13	B.	20	Rame E. 7 miles	27	M.
L.	A	,,	M.	20	,, 6 miles	27	M.
LI.	A	,,	M.	20	,, 5 miles	27	M.
LII.	A	,,	S.	20	,, 4 miles	26	T.
LIII.	A	1.viii.13	S.	20	Eddystone N. 2 miles M.H.	36	R.
LIV.	A	2.viii.13	S.	20	,, N. 3 miles M.H.	ca. 35	R.
LV.	A	,,	S.	20	,, N. $5\frac{1}{2}$ miles M.H.	38	R.

TABLE I. LIST OF STATIONS.—*Continued.*

Explanation of abbreviations. S.=surface. M.=midwater. B.=bottom. M.H.=midnight haul.

No. of Haul.		Date.	Depth of Capture.	Duration of Haul in min.	Locality.	Total Depth in. fms.	Chart Area.
LVI.	A	2.viii.13	M.	20	Eddystone N. 6 miles M.H.	38	Q.R.
LVII.	A	,,	M.	20	,, N.E. 6 miles M.H.	37	R.
LVIII.	A	,,	S.	20	,, N.N.E. 6 miles M.H.	38	Q.
LIX.	A	6.viii.13	—	20	Lynher River above H.M.S. *Defiance*	<10	U.
LX.	A	7.viii.13	S.	20	Eddystone N. 1 mile	33	R.
LXI.	A	,,	M.	20	,, N. 3½ miles	36	R.
LXII.	A	,,	B.	20	,, N. 6 miles	38	Q.R.
LXIII.	A	,,	M.	20	,, N. 5 miles	38	R.
LXIV.	A	11.viii.13	M.	20	,, N. 3 miles	34	R.
LXV.	A	,,	B.	20	,, N. 3 miles	34	R.
LXVI.	A	,,	M.	20	,, N.E. by N. 3½ miles	38	R.
LXVII.	A	,,	S.	20	,, N.E. 3½ miles	38	R.
LXVIII.	A	,,	M.	20	,, S.S.W. 2½ miles	29	S.
LXIX.	A	,,	B.	20	,, S.W. by S. 3 miles	28	S.
LXX.	A	,,	M.	20	Between Rame Hd. and Penlee Pt.	<10	T.
LXXI.	A	13.viii.13	S.	20	Off Downderry towing W. M.H.	<10	L.
LXXII.	A	,,	S.	20	Bell Buoy, Looe M.H.	<10	L.
LXXIII.	A	,,	S.	20	Looe N. 2 miles M.H.	13	M.
LXXIV.	A	,,	M.	20	,, N. 4 miles M.H.	25	M.
LXXV.	A	,,	S.	20	,, N. 6 miles M.H.	27	M.
LXXVI.	A	14.viii.13	S.	20	Eddystone E. 6 miles M.H.	35	O.
LXXVII.	A	18.viii.13	M.	20	,, W. by N. 2½ miles	32	S.
LXXVIII.	A	,,	B.	20	,, ,, 3 miles	33	S.
LXXIX.	A	,,	B.	20	,, ,, 4 miles	35	X.
LXXX.	A	,,	M.	20	New Grounds, Plymouth Sound	<10	V.
LXXXI.	A	19.viii.13	B.	40	Bigbury Bay	10–20	Y.
LXXXII.	A	,,	M.	20	Eddystone W. by S. 9 miles	24	W.
LXXXIII.	A	,,	B.	20	,, ,, ,,	24	W.
LXXXIV.	A	21.viii.13	M.	20	Rame E. 3½ miles	25	T.
LXXXV.	A	,,	B.	20	,, E. by S. 3 miles	22	T.
LXXXVI.	A	,,	S.	20	,, E.S.E. 3 miles	19	T.
LXXXVII.	A	,,	M.	20	,, S.E. by E. 3 miles	14	T.
LXXXVIII.	A	22.viii.13	M.	20	Cawsand Bay	<10	T.U.
LXXXIX.	A	,,	B.	20	,, ,,	<10	T.U.
XC.	A	,,	B.	20	Off Little Penlee	<10	T.

XCI.	A	25.viii.13	S.	20	Eddystone N. 5 miles M.H.	38	R.
XCII.	A	,,	M.	20	,, N. by E. 5 miles M.H.	38	R.
XCIII.	A	,,	M.	20	,, N.N.E. 5 miles M.H.	38	R.
XCIV.	A	,,	M.	20	,, N.E. by N. 5 miles M.H.	38	R.
XCV.	A	,,	M.	20	,, N.E. 5 miles M.H.	38	R.
XCVI.	A	,,	B.	20	,, N.E. by E. 5 miles M.H.	38	O.
XCVII.	A	,,	B.	20	,, E.N.E. 5 miles M.H.	36	O.
XCVIII.	A	,,	M.	20	,, ,, ,,	36	O.
XCIX.	A	26.viii.13	M.	20	,, N.W. 3 miles	31	R.
C.	A	27.viii.13	M.	20	,, W.S.W. 5 miles	28	X.
CI.	A	,,	M.	20	,, W. by S. 4½ miles	30	X.
CII.	A	,,	M.	20	,, W. by S. 4 miles	30	S.X.
CIII.	A	29.viii.13	M.	20	,, N.E. by N. 3½ miles	38	R.
CIV.	A	,,	B.	20	,, N.E. 4½ miles	38	R.
CV.	A	,,	M.	20	Eddystone N.E. 5 miles	38	R.
CVI.	A	,,	B.	20	,, N.E. 6 miles	37	R.
CVII.	A	1.ix.13	M.	20	Rame E. 3½ miles	25	T.
CVIII.	A	,,	M.	20	,, 4½ miles	27	M.T.
CIX.	A	,,	B.	20	,, 5½ miles	27	M.
CX.	A	,,	B.	20	,, 6½ miles	27	M.
CXI.	A	3.ix.13	M.	20	Eddystone N.N.W. 2 miles M.H.	32	R.
CXII.	A	,,	S.	20	,, ,, ,, M.H.	32	R.
CXIII.	A	,,	S.	20	,, S.W. 3 miles M.H.	29	S.
CXIV.	A	5.ix.13	B.	20	,, N.E. 8½ miles	39	P.
CXV.	A	,,	M.	20	,, ,, 9 miles	39	P.
CXVI.	A	,,	M.	20	,, ,, 10 miles	40	P.
CXVII.	A	,,	M.	20	,, ,, 10½ miles	40	P.
CXVIII.	A	,,	M.	20	,, ,, 4 miles	37	R.
CXIX.	A	,,	M.	20	,, ,, 3½ miles	37	R.
CXX.	A	8.ix.13	M.	20	Rame N. by W. 2 miles	25	T.
CXXI.	A	,,	B.	20	,, ,, ,,	25	T.
CXXII.	A	,,	B.	20	Eddystone S.W. 4 miles	28	S.
CXXIII.	A	,,	M.	20	,, S.W. by S. 2½ miles	29	S.
CXXIV.	A	,,	B.	20	,, ,, ,,	29	S.
CXXV.	A	9.ix.13	M.	20	Rame Hd. E.N.E. 1½ miles	25	T.
CXXVI.	A	,,	B.	20	,, E. by N. 3 miles	27	T.
CXXVII.	A	,,	M.	20	,, E. 4 miles	26	T.
CXXVIII.	A	,,	M.	20	,, E. 6 miles	27	M.
CXXIX.	A	,,	S.	20	Looe N. 4 miles	25	M.
CXXX.	A	10.ix.13	M.	20	Off Downderry	<10	L.
CXXXI.	A	11.ix.13	M.	20	Eddystone S.W. 5 miles	27	T.

TABLE I. LIST OF STATIONS.—*Continued.*

Explanation of abbreviations. S.=surface. M.=midwater. B.=bottom. M.H.=midnight haul.

No. of Haul.		Date.	Depth of Capture.	Duration of Haul in min.	Locality.	Total Depth in fms.	Chart Area.
CXXXII.	A	11.ix.13	B.	20	Eddystone S.W. $3\frac{1}{2}$ miles	28	S.
CXXXIII.	A	,,	M.	20	,, ,, 3 miles	29	S.
CXXXIV.	A	,,	M.	20	,, S.S.W. $1\frac{1}{2}$ miles	30	S.
CXXXV.	A	12.ix.13	M.	20	Rame Hd. E. by N. 2 miles	27	T.
CXXXVI.	A	,,	M.	20	,, N.E. 4 miles	28	S.
CXXXVII.	A	,,	M.	20	Eddystone S. by W. $3\frac{1}{2}$ miles	29	S.
CXXXVIII.	A	,,	M.	20	,, S. 2 miles	32	S.
CXXXIX.	A	,,	M.	20	,, N. by W. 2 miles	ca. 34	R.
CXL.	A	15.ix.13	M.	20	,, S.W. $3\frac{1}{2}$ miles	28	S.
CXLI.	A	,,	B.	20	,, W. by S. $3\frac{1}{2}$ miles	30	S.
CXLII.	A	,,	B.	60	,, S.W. 2 miles	29	S.
CXLIII.	A	,,	M.	20	,, ,, ,,	29	S.
CXLIV.	A	,,	M.(below)	20	,, ,, ,,	29	S.
CXLV.	A	,,	M.	20	,, S.W. by W. 2 miles	29	S.
CXLVI.	A	16.ix.13	M.	20	Bigbury Bay, Borough Is. E. by S. 2 miles	17	Y.
CXLVII.	A	,,	B.	20	,, ,, ,, E. $1\frac{1}{2}$ miles	15	Y.
CXLVIII.	A	,,	B.	20	,, ,, ,, N.E.	15	Y.
CXLIX.	A	,,	M.	20	Bolt Tail S.S.E. 1 mile	<10	Z.
CL.	A	19.ix.13	B.	20	Rame Hd. N.N.W. $3\frac{1}{2}$ miles	25	W.
CLI.	A	,,	M.	20	Eddystone S.W. by S. $2\frac{1}{2}$ miles	29	S.
CLII.	A	,,	M.	20	,, S.W. $1\frac{1}{2}$ miles	29	S.
CLIII.	A	,,	M.	20	,, S.S.W. $1\frac{1}{2}$ miles	30	S.
CLIV.	A	,,	B.	20	,, S. $1\frac{1}{2}$ miles	31	S.
CLV.	A	20.ix.13	B.	20	,, S.W. 1 mile	ca. 29	S.
CLVI.	A	,,	M.	20	,, W.S.W. $\frac{1}{2}$ mile	24	S.
CLVII.	A	22.ix.13	B.	20	Rame Hd. E. $\frac{1}{4}$ mile	14	T.
CLVIII.	A	,,	M.	20	Polperro N. 4 miles	25	M.
CLIX.	A	,,	B.	20	,, N.N.W. $4\frac{1}{2}$ miles	27	M.
CLX.	A	,,	B.	20	Looe Is. N. 4 miles	ca. 27	M.
CLXI.	A	,,	M.	20	Looe N. 4 miles	25	M.
CLXII.	A	24.ix.13	M.	20	Between Mewstone Buoy and Stoke Pt.	ca. 10	W.
CLXIII.	A	,,	M.(below)	20	,, ,, ,, and Shagstone	<10	W.
CLXIV.	A	,,	M.	40	Jennycliff Bay	<10	V.
CLXV.	A	,,	B.	20	,, ,,	<10	V.
CLXVI.	A	25.ix.13	B.	20	Between Mewstone Buoy and Stoke Pt.	ca. 10	W.

CLXVII.	A	25.ix.13	M.	20	Between Mewstone Buoy and Stoke Pt.	ca. 10	W.
CLXVIII.	A	,,	S.	20	,, ,, ,, ,,	ca. 10	W.
CLXIX.	A	,,	M.	20	Eddystone W.S.W. 3 miles	30	S.
CLXX.	A	,,	B.	20	,, ,, 2½ miles	31	S.
CLXXI.	A	26.ix.13	M.	40	Rame E. 5 miles	27	M.
CLXXII.	A	,,	M.	20	,, 5½ miles	27	M.
CLXXIII.	A	,,	B.	20	,, ,,	27	M.
CLXXIV.	A	,,	B.	40	,, 6 miles	27	M.
CLXXV.	A	,,	M.	20	,, ,,	27	M.
CLXXVI.	A	,,	B.	20	,, 4½ miles	27	M.T.
CLXXVII.	A	,,	S.	20	,, 4 miles	26	T.
CLXXVIII.	A	29.ix.13	M.	20	Eddystone S.S.W. 2 miles	29	S.
CLXXIX.	A	,,	B.	20	,, S. by E. 2 miles	32	S.
CLXXX.	A	30.ix.13	M.	20	Mewstone Buoy ¾ mile N.	ca. 18	W.
CLXXXI.	A	,,	B.	20	,, ,, ,,	ca. 18	W.
CLXXXII.	A	,,	M.	20	Rame Hd. E. by N. 2 miles	ca. 27	T.
CLXXXIII.	A	,,	M.	20	,, E.N.E. 2 miles	ca. 26	T.
CLXXXIV.	A	1.x.13	B.	20	Whitsand Bay W.	10–20	L.M.
CLXXXV.	A	,,	M.	20	,, ,,	10–20	L.M.
CLXXXVI.	A	,,	B.	20	Rame Hd. N.W. ¼ mile	14	T.
CLXXXVII.	A	10.x.13	B.	20	Mewstone E. ¼ mile	10	W.
CLXXXVIII.	A	13.x.13	B.	20	,, ½ mile	11	W.
CLXXXIX.	A	14.x.13	B.	20	Rame Hd. E. by N. 3 miles	27	T.
CXC.	A	,,	M.	20	,, ,, 3½ miles	27	T.
CXCI.	A	,,	M.	20	,, E. by S. 4 miles	ca. 23	T.
CXCII.	A	24.x.13	M.	20	Rame E. 6 miles	27	M.
CXCIII.	A	,,	B.	20	,, E. by N. 6 miles	26	M.
CXCIV.	A	,,	M.	20	,, E.N.E. 6½ miles	ca. 28	N.
CXCV.	A	27.x.13	B.	40	Cawsand Bay	<10	T.U.
CXCVI.	A	,,	B.	20	Mewstone S.E. by E. 2 miles	ca. 12	W.
CXCVII.	A	7.xi.13	B.	20	Rame Hd. N. 1 mile	24	T.
CXCVIII.	A	,,	M.	20	,, N.N.E. 2½ miles	27	T.
CXCIX.	A	13.xi.13	B.	20	South of Breakwater	<10	W.
CC.	A	,,	B.	20	Penlee N.W. by W. 2 miles	ca. 15	W.
CCI.	A	,,	B.	20	Between Penlee and Rame Hd.	<10	T.
CCII.	A	,,	M.	20	,, ,, ,, Breakwater	<10	T.
CCIII.	A	26.xi.13	B.	20	Eddystone S.W. 5 miles	27	T.
CCIV.	A	,,	B.	20	,, S.W. by S. 3 miles	29	S.
CCV.	A	,,	M.	20	,, S. 1 mile	31	S.

CLUPEIDÆ.

The Clupeoids, which are recorded in Table XXV, have not been fully determined specifically, though the material contains examples of three species, *Clupea harengus* L., *C. sprattus* L. and *C. pilchardus* Walb. A survey of Table 2 shows a maximum frequency in numbers during May and June, and the records for these two months are chiefly those of the Sprat, though Herring and Pilchard are also represented. The increase in numbers during September and October, after a decrease in July and August, was due largely to the capture of larval Pilchards, which were easily identified by the presence of an oil globule and segmented yolk. The occurrence of the eggs and early stages of *C. pilchardus* during a considerable part of the year raises the important question (which will be discussed in a later contribution) as to the periods of spawning for this species.

SYNGNATHIDÆ.

TABLE III.

Record of Number and Size of Individuals.

No. of Haul.	Date.	Depth.	S. acus.		S. rostellatus.		N. æquoreus.	
			No.	Size mm.	No.	Size mm.	No.	Size mm.
IV. H	22.v.06	B.	3	13–15	—	—	—	—
XVI. H	28.vi.06	M.	—	—	1	17	—	—
XXV. H	11.ix.06	B.	—	—	4	24–65	—	—
XXX. H	4.x.06	B.	—	—	1	27	—	—
LXVIII. H	19.vi.08	B.	1	12	—	—	—	—
LXXVII. H	2.vii.08	B.	1	19	—	—	—	—
LXXX. H	15.vii.08	B.	1	22	—	—	—	—
XCIV. H	26.viii.08	M.	2	23	—	—	—	—
CXIV. H	6.vii.09	S.	1	18·5	—	—	—	—
CXXVII. H	19.vii.09	S.	—	—	1	23	—	—
X. A	16.vi.13	B.	—	—	1	20	—	—
XLI. A	28.vii.13	M.	—	—	1	14·5	—	—
XLII. A	,,	M.	—	—	1	25·5	—	—
XLIII. A	,,	S.	—	—	1	26	—	—
XLIV. A	29.vii.13	—	—	—	—	—	1	9
XLVI. A	,,	M.	—	—	1	14	—	—
XLVIII. A	30.vii.13	B.	—	—	2	21–29·5	—	—
LIV. A	2.viii.13	S.	1	56	—	—	—	—
LXXXI. A	19.viii.13	B.	—	—	1	33	—	—
LXXXVIII. A	22.viii.13	M.	—	—	3	17–20	—	—
LXXXIX. A	,,	B.	—	—	4	17·5–22·5	—	—
XC. A	,,	B.	—	—	17	18–33·5	—	—
XCI. A	25.viii.13	S.	1	43	—	—	—	—
CVIII. A	1.ix.13	M.	—	—	—	—	1	14·5
CXXI. A	8.ix.13	B.	1	21	—	—	—	—
CXXII. A	,,	B.	—	—	—	—	1	22
CLX. A	22.ix.13	B.	—	—	1	36·5	—	—
CLXV. A	24.ix.13	B.	—	—	3	16–42	—	—
CLXXXIV. A	1.x.13	B.	—	—	1	14	—	—
CLXXXIX. A	14.x.13	B.	—	—	—	—	1	11
CXCVIII. A	7.xi.13	M.	—	—	1	27	1	15

TABLE II. MONTHLY SUMMARY OF CLUPEOIDS.

Explanation of Abbreviations
∝ = Several thousands.
M. = Many.
SIZE = Length in mm.

	March.		April.		May.		June.		July.		August.		September.		October.		November.	
	No.	Size.	No.	Size.	No.	Size.	No.	Size.	No.	Size.	No.	Size.	No.	Size.	No.	Size.	No.	Size.
1906	—	—	—	—	∝	9–47	112	9–22	53	10·5–24	—	—	2	4·5–18	1	7	—	—
1907	24	3·5–20	20	5–14·5	—	—	3	9–12	1	16	—	—	—	—	—	—	—	—
1908	—	—	—	—	55	4–21	M.	6–24	71	7–27	3	20	—	—	—	—	—	—
1909	—	—	7	7–15	14	12–27	117	10–41	127	7·5–22·5	11	10–22·5	—	—	—	—	—	—
1913	—	—	—	—	—	—	856	8–32·5	59	10–25	90	9·5–36	264	3·4–24	486	3·5–24	93	5·5–21
Total	24	3·5–20	27	5–15	∝	4–47	M.	6–32·5	311	7–27	104	8·7–36	266	3·4–24	487	3·5–24	93	5·5–21

The measurements recorded in Tables 2 to 25 were taken from specimens preserved in 5% Formalin.

SYNGNATHIDÆ.

Syngnathus acus L. *S. rostellatus* Nilss. *Nerophis æquoreus* L.

Larval and post-larval pipe-fishes occurred sparingly in the young-fish trawl material. They represent types of three species, of which the commonest is *Syngnathus rostellatus* Nilss. Most of the specimens were taken in bottom hauls close inshore, with a higher frequency from the mouth of the Sound inwards. A few were taken offshore, notably two older stages of *S. acus*, in surface hauls at midnight from 3 to 5 miles south of the Eddystone rocks.

AMMODYTIDÆ.

Ammodytes sp.

According to the records in Table 25, the frequency of the sand-eel larvæ and post-larvæ is greatest between the thirty and forty fathom lines, decreases slightly between the twenty and thirty, and is practically limited to a few records under twenty fathoms.

The summary (Table 4) shows a gradual increase in numbers until August, and a decrease in September, after which no individuals were captured. There is thus a comparatively dense spawning period in the middle months of the year, which seems to correspond to the period assigned to *A. lanceolatus.* Ehrenbaum considers the lesser sand-eel (*A. tobianus*) an earlier spawner. The period of maximum hatching for this species in the North Sea lies between January and March.

Both species are represented in the collection, but I have been unable to separate out the two forms as they show no obvious specific characters which would ensure accuracy in identification.

GADIDÆ.

Gadus pollachius L. *G. merlangus* L. *G. minutus* O. F. Müller.
G. luscus L.

These four species of Gadoids have been brought together in Table 5. It will be seen that the maximum number of individuals lies in May and June, and that these are mostly whiting (*G. merlangus*). The pollack is an early spawner, but this may not account altogether for the scarcity of post-larval forms, especially when one considers the tolerable abundance of older stages in the littoral areas in summer. The records of *G. minutus* and *G. luscus* are important, and may help to throw some light on the spawning periods of these two closely allied species. *G. luscus* larvæ were taken in September, October, and November, 1913. Investigations were carried on at intervals during December of the same year, and during January and February, 1914, and eggs of this

TABLE IV.

MONTHLY SUMMARY OF AMMODYTES SP.

	MARCH.		APRIL.		MAY.		JUNE.		JULY.		AUGUST.		SEPTEMBER.		OCTOBER.	
	No.	Size.	No.	Size.	No.	Size.	No.	Size.	No.	Size.	No.	Size.	No.	Size.	No.	Size.
1906	—	—	—	—	20	6–29	40	6·5–18	17	7–23	—	—	1	15	—	—
1907	1	8·5	6	6·5–12·5	—	—	—	—	12	13–22	—	—	—	—	—	—
1908	—	—	—	—	—	—	84	6–23	100	5–20	26	5–19	—	—	—	—
1909	—	—	1	12	—	—	16	10–32	57	7–29	18	5–22	—	—	—	—
1913	—	—	—	—	—	—	51	14–104	144	6–28	462	4·5–25	13	5·5–24	—	—
Total	1	8·5	7	6·5–12·5	20	6–29	191	6–104	330	5–29	506	4·5–25	14	5·5–24	—	—

species were still abundant in the tow-nets, while larvæ were occasionally taken. Ova of *G. minutus* were not observed during this period, but it is possible that they may have been represented in the later February catches. There is evidence from the table that the bib spawns in February, March, and April, if not later.

In the four species of Gadus, frequency is high for the early pelagic stages beyond the twenty-fathom line, but gradually diminishes in intensity in the same area as the individuals get older.

TABLE V.

RECORD OF GADUS SP.

No. of Haul.		Date.	Depth.	G. pollachius. No.	G. pollachius. Size.	G. merlangus. No.	G. merlangus. Size.	G. luscus. No.	G. luscus. Size.	G. minutus. No.	G. minutus. Size.
II.	H	22.v.06	S.	2	5–10	11	5–17	—	—	—	—
III.	H	,,	M.	1	10–15	158	5–15	2	5–10	3	5–15
IV.	H	,,	B.	—	—	324	4–15	7	5–10	1	5
V.	H	,,	B.	—	—	16	5–17	—	—	2	8–11
VI.	H	30.v.06	B.	1	7·5	29	4–9	—	—	26	4–9
VII.	H	,,	S.	—	—	5	7·5–10	—	—	—	—
VIII.	H	,,	B.	—	—	1	9	—	—	—	—
IX.	H	20.vi.06	S.	—	—	1	9	—	—	—	—
X.	H	,,	M.	—	—	1	16·5	—	—	—	—
XI.	H	,,	B.	—	—	2	7	—	—	3	12·5–17
XIII.	H	,,	M.	—	—	7	5–10	—	—	—	—
XIV.	H	,,	B.	—	—	4	5–9	—	—	—	—
XV.	H	28.vi.06	S.	—	—	1	11	—	—	—	—
XVII.	H	,,	B.	—	—	14	6–11	—	—	—	—
XVIII.	H	,,	M.	—	—	2	7·5–10	—	—	—	—
XIX.	H	20.vii.06	?	—	—	5	7·5–8	—	—	—	—
XX.	H	,,	?	—	—	6	6–12·5	—	—	—	—
XXXI.	H	25.iii.07	S.	4	4·5–5·5	—	—	—	—	3	4·5–6·5
XXXII.	H	,,	M.	19	3–5	2	3–4	—	—	11	5–7
XXXIII.	H	11.iv.07	M.	15	4–7·5	20	4–8	1	7·5	—	—
XXXIV.	H	,,	B.	22	3·5–6·5	19	3·5–7·5	1	5·5	—	—
XXXV.	H	6.vi.07	B.	—	—	72	5·5–40	—	—	2	10–15
XXXVI.	H	,,	B.	—	—	18	10–40	1	9	—	—
XLII.	H	28.v.08	S.	—	—	—	—	—	—	1	4
XLIII.	H	,,	M.	—	—	25	6–11	—	—	7	6–8
XLIV.	H	,,	B.	—	—	14	7–11	—	—	27	7–13
XLV.	H	1.vi.08	S.	—	—	—	—	—	—	—	—
XLVI.	H	,,	M.	—	—	3	4–9	—	—	—	—
XLVII.	H	,,	B.	—	—	9	5–14·5	—	—	—	—
XLVIII.	H	,,	S.	—	—	1	12	—	—	—	—
XLIX.	H	,,	M.	—	—	1	12	—	—	—	—
L.	H.	,,	B.	—	—	7	6–11	—	—	3	6–9
LI.	H	4.vi.08	S.	—	—	2	5	1	11	—	—
LII.	H	,,	B.	—	—	3	3–4	1	7·8	—	—
LV.	H	5.vi.08	S.	—	—	8	5–15	—	—	—	—
LVI.	H	,,	B.	—	—	12	5·5–14	1	8·5	—	—
LVIII.	H	10.vi.08	B.	—	—	23	6–14	—	—	—	—
LIX.	H	12.vi.08	S.	—	—	—	—	—	—	—	—
LX.	H	,,	B.	—	—	22	5–11	1	11	3	17–28
LXI.	H	15.vi.08	B.	—	—	21	6–9	—	—	36	30–48
LXII.	H	19.vi.08	S.	—	—	4	5–15	—	—	—	—
LXIV.	H	,,	M.	—	—	—	—	—	—	—	—
LXV.	H	,,	B.	—	—	9	4–16·5	—	—	—	—

TABLE V.—*Continued*

Record of Gadus Sp.

No. of Haul.		Date.	Depth.	G. pollachius.		G. merlangus.		G. luscus.		G. minutus.	
				No.	Size.	No.	Size.	No.	Size.	No.	Size.
LXVI.	H	19.vi.08	B.	—	—	20	5–11	2	7–8	13	14–18
LXVIII.	H	,,	B.	—	—	5	9–12·5	—	—	—	—
LXX.	H	23.vi.08	M.	—	—	4	10–12	—	—	—	—
LXXI.	H	,,	B.	—	—	?	8–13	—	—	3	17–18
LXXII.	H	,,	B.	—	—	1	7·3	—	—	—	—
LXXIII.	H	25.vi.08	B.	—	—	2	11–14	—	—	—	—
LXXIV.	H	30.vi.08	B.	—	—	6	5–8	—	—	—	—
LXXV.	H	,,	B.	—	—	—	—	1	4	—	—
LXXX.	H	15.vii.09	B.	—	—	1	15	—	—	—	—
XCV.	H	28.iv.08	S.	—	—	4	5–10	—	—	—	—
XCVI.	H	,,	B.	—	—	6	7–10	1	6	3	15–18
XCVII.	H	3.v.09	?	—	—	11	5–15	—	—	—	—
XCIX.	H	13.v.09	M.	—	—	20	6·5–11	—	—	14	7–12
C.	H	24.v.09	S.	—	—	2	8–8·5	—	—	—	—
CI.	H	,,	B.	1	22	11	7·5–10	—	—	—	—
CII.	H	2.vi.09	S.	—	—	4	6–12	1	7	—	—
CIII.	H	,,	M.	—	—	11	6–12	—	—	—	—
CIV.	H	,,	B.	1	23	26	7–13	1	6	1	10
CV.	H	10.vi.09	S.	1	28	2	9–13	—	—	—	—
CVI.	H	,,	B.	13	23–42	5	6·5–14	—	—	—	—
CVIII.	H	22.vi.09	B.	—	—	4	8–12	—	—	—	—
CIX.	H	25.vi.09	S.	4	22	14	8–15	—	—	—	—
CX.	H	,,	B.	—	—	3	7–7·5	—	—	—	—
CXIII.	H	29.vi.09	B.	—	—	4	7·5–8	—	—	3	8–13·5
CXV.	H	6.vii.09	B.	1	6	—	—	—	—	—	—
CXVI.	H	8.vii.09	?	—	—	—	—	—	—	1	54
CXVIII.	H	13.vii.09	M.	—	—	—	—	—	—	1	49
CXXI.	H	20.vii.09	M.	—	—	1	9	—	—	1	26
CXXII.	H	,,	B.	—	—	1	12·5	—	—	—	—
CXXIV.	H	6.viii.09	M.	—	—	1	62	—	—	—	—
I.	A	6.vi.13	S.	—	—	2	5·6–7·5	—	—	—	—
III.	A	,,	B.	—	—	—	—	—	—	5	5–7
V.	A	12.vi.13	M.	—	—	1	8·05	—	—	—	—
VI.	A	13.vi.13	M.	—	—	29	6–10	—	—	—	—
VII.	A	,,	S.	—	—	3	7–10·4	—	—	—	—
VIII.	A	,,	M.	—	—	62	7–12·25	—	—	—	—
IX.	A	,,	B.	—	—	25	7·3–14	—	—	—	—
X.	A	16.vi.13	B.	—	—	5	7–10.8	—	—	—	—
XII.	A	18.vi.13	S.	—	—	2	8–8·2	—	—	—	—
XIII.	A	,,	M.	—	—	—	—	—	—	3	11·69
XIV.	A	,,	B.	—	—	3	9·5–12	—	—	—	—
XVI.	A	19.vi.13	M.	—	—	1	12·39	—	—	—	—
XX.	A	20.vi.13	S.	—	—	1	7	—	—	—	—
XXI.	A	24.vi.13	S.	—	—	6	7–12·6	—	—	—	—
XXII.	A	27.vi.13	M.	—	—	3	6·9–9·5	—	—	—	—
XXV.	A	7.vii.13	B.	—	—	1	10	—	—	—	—
XXXIX.	A	25.vii.13	S.	—	—	3	27–52·5	—	—	—	—
XLII.	A	28.vii.13	M.	—	—	1	50	—	—	—	—
CXXIII.	A	8.ix.13	M.	—	—	—	—	1	8	—	—
CLVII.	A	22.ix.13	B.	—	—	—	—	1	8	—	—
CLXXI.	A	26.ix.13	M.	—	—	—	—	1	6·23	—	—
CLXXVI.	A	,,	B.	—	—	—	—	1	5·76	—	—
CLXXVIII.	A	29.ix.13	M.	—	—	—	—	1	4	—	—
CLXXXVIII.	A	13.x.13	B.	—	—	—	—	1	4·69	—	—
CLXXXIX.	A	14.x.13	B.	—	—	—	—	1	3·35	—	—
CXCII.	A	24.x.13	M.	—	—	—	—	2	4–4·9	—	—
CXCIV.	A	,,	M.	—	—	—	—	1	4·89	—	—
CCV.	A	26.xi.13	M.	—	—	—	—	1	3.4	—	—

GADIDÆ.

Molva molva L.

Twenty post-larvæ of the common ling were taken in May and June. These ranged from 5 mm. to 13·09 mm. With the exception of five specimens taken in Cawsand Bay, all occurred beyond the twenty-fathom contour line, and the majority of these between twenty and thirty fathoms, at no great distance from the shore, and off the entrance to the Sound. All the stages are similar to those described and figured by Schmidt in "Medd. fra Komm. for Havund. Serie Fiskeri," Bind II, 1906.

These records suggest a similar, though perhaps less extended, spawning period to that for the North Sea, which Ehrenbaum gives as March to May, with a maximum in April.

TABLE VI.

RECORD OF MOLVA MOLVA L.

No. of Haul.	Date.	Depth.	No.	Size.
IV. H	22.v.06	B.	1	5
V. H	,,	B.	1	9
XVII. H	28.vi.06	B.	2	10–15
XLIII. H	28.v.08	M.	3	?
LV. H	5.vi.08	S.	1	7·5
LVI. H	,,	B.	1	7
LX. H	12.vi.08	B.	1	8
LXI. H	15.vi.08	B.	2	?
LXV. H	19.vi.08	M.	1	9·5
LXXIV. H	30.vi.08	B.	1	5
LXXV. H	30.vi.09	B.	1	8
CIII. H	2.vi.09	M.	1	13
III. A	11.vi.13	M.	1	6
XVI. A	19.vi.13	M.	2	8·75–10·7
XXII. A	27.vi.13	M.	1	13·09

GADIDÆ.

Raniceps raninus L.

The records of the lesser forkbeard are confined to 8 specimens obtained from 13th August to 8th September, 1913. A spawning period from July to August is thus indicated. For the North Sea, Ehrenbaum* has given from middle of June to middle of August.

All were taken between the twenty and forty fathom contour lines. The occurrence of these early stages is interesting, when it is considered that the adult forkbeard is distinctly rare in the neighbourhood. Two early post-larvæ of 4·5 mm. bridge the gap between Ehrenbaum's 3 mm. larva and Schmidt's* 5 mm. early post-larva. The general outline of the fish (with the rounded profile of the head) resembles Schmidt's 5 mm. specimen very closely. Pigment is slightly more pronounced, especially over the abdominal surface, where large stellate chromatophores of a rusty-brown colour are more closely packed on the dorsal part of this region. Chromatophores also appear on the suborbital region.

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* Nordisches Plankton. Vol. II. Eier und Larven von Fischen. 1905.

TABLE VII.

RECORD OF RANICEPS RANINUS L

No. of Haul.		Date.	Depth.	No.	Size.
LXXIV.	A	13.viii.13	M.	3	4·5–9
LXXIX.	A	18.viii.13	B.	1	17
XCV.	A	25.viii.13	M.	1	17
CII.	A	27.viii.13	M.	1	18·5
CXXII.	A	8.ix.13	B.	1	4·5
CXXVII.	A	9.ix.13	M.	1	5·5

GADIDÆ.

Onos mustela L. *O. tricirratus* Bl. *O. cimbrius* L.

I can only identify with certainty one post-larva 3·75 mm. in length as *O. cimbrius*. It was secured at the surface in haul 58 A, on 2nd August, 1913, 6 miles S.S.W. of the Eddystone rocks. It has the single typical post-anal bar and the long black ventrals as described by Ehrenbaum,† and lies between his Fig. f and Fig. g. Only two adult specimens have come under my notice. One, 22·5 cm., was taken in a commercial beam-trawl on the outer Eddystone Grounds in November, 1912; the other, 15 cm., in a mosquito-net attached to the shackle of the otter-board, 3½ miles W.S.W. of Rame Head on 2nd September, 1913. These have the first ray of the first dorsal fin extremely elongated.

Early post-larvæ of *O. tricirratus* were not observed, and only the later stages, with the three barbels developed, could be identified with accuracy.

O. mustela occurred from March to September with an intensity in June. The characters of these young stages are by no means obvious, and it is just possible that a few may belong really to *O. tricirratus*. The real difficulty in identifying the rocklings at Plymouth will be overcome when the early stages of *O. tricirratus* are worked out more fully.

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* Medd. fra Komm. for Havund. Serie Fiskeri. Bind. II, Nr. 8. 1907.

† Nord. Plank. Vol. II, p. 280.

TABLE VIII.

Record of Onos Sp.

No. of Haul.		Date.	Depth.	O. mustela.		O. tricirratus.	
				No.	Size.	No.	Size.
IV.	H	22.v.06	B.	1	5	—	—
XII.	H	20.vi.06	S.	1	4	—	—
XIII.	H	,,	M.	1	10	1	30
XIV.	H	,,	B.	1	4	—	—
XVI.	H	28.vi.06	M.	2	2·7–6	—	—
XX.	H	20.vii.06	?	1	5	—	—
XXXIV.	H	11.iv.07	B.	1	5·5	—	—
XXXIX.	H	10.vii.07	B.	—	—	1	32
XLV.	H	1.vi.08	S.	4	8·7–10·5	—	—
XLVI.	H	,,	M.	1	7	—	—
XLVIII.	H	,,	S.	1	6·8	—	—
LV.	H	5.vi.08	S.	1	4·5	—	—
LVIII.	H	10.vi.08	B.	2	5·5–6	—	—
LIX.	H	12.vi.08	S.	5	6–8	—	—
LX.	H	,,	B.	1	6	—	—
LXXIV.	H	30.vi.08	B.	3	3–4	—	—
LXXXII.	H	20.vii.08	M.	1	5·2	—	—
CV.	H	10.vi.09	S.	2	3·3–3·4	—	—
CXVI.	H	8.vii.09	?	1	8·5	—	—
CXVIII.	H	13.vii.09	M.	1	7·5	—	—
CXXII.	H	20.vii.09	?	1	6·5	—	—
IV.	A	11.vi.13	S.	1	7	—	—
XIII.	A	18.vi.13	M.	—	—	1	19
XIV.	A	,,	B.	—	—	1	25
XVII.	A	19.vi.13	M.	2	4·2–4·4	—	—
XIX.	A	20.vi.13	M.	1	6·8	—	—
XX.	A	,,	S.	—	—	1	36·5
XXIII.	A	30.vi.13	B.	1	5·39	—	—
XXV.	A	7.vii.13	B.	1	19	—	—
XXXII.	A	15.vii.13	S.	1	4·2	—	—
XXXIX.	A	25.vii.13	S.	1	31	—	—
LIII.	A	1.viii.13	S.	—	—	2	25–25.5
LVII.	A	2.viii.13	M.	—	—	2	17–23
LXIII.	A	7.viii.13	M.	1	4·89	—	—
LXIV.	A	11.viii.13	M.	—	—	1	28
LXXVIII.	A	18.viii.13	B.	—	—	1	37·5
CXXIX.	A	9.ix.13	S.	1	8	—	—

MULLIDÆ.

Mullus surmuletus L.

Records of post-larval red mullet were extremely few, and confined to June, July, and August. This indicates a spawning period from May to July, which corresponds to the known period of spawning for this species. There is unequal representation during the five years, but, owing to the scarcity of young forms recorded, no actual deduction can be made as to the yearly fluctuations of the adults. Their numbers seem to be clearly diminishing in the neighbourhood.

TABLE IX.

RECORD OF MULLUS SURMULETUS L.

No. of Haul.		Date.	Depth.	No.	Size
XVII.	H	28.vi.06	B.	2	5–6·5
XIX.	H	20.vii.06	?	1	6
XX.	H	,,	?	2	5–5·5
XXI.	H	27.vii.06	?	11	4·5–5·5
XXII.	H	,,	?	2	5·5–7
CXIII.	H	29.vi.09	B.	2	7
CXVII.	H	13.vii.09	S.	1	7
CXX.	H	20.vii.09	S.	5	5–6
CXXI.	H	,,	?	6	5·5–7·5
CXXII.	H	,,	?	4	6–7·7
CXXIV.	H	6.viii.09	M.	4	4·5–6·5
CXXV.	H	,,	B.	3	5–6
LVII.	A	2.viii.13	M.	2	4·69

LABRIDÆ.

Labrus bergylta Asc. *Ctenolabrus rupestris* L.

I have referred the pelagic young stages to the above two species which are recorded in Table 25. *Ctenolabrus rupestris* L. is quite a distinct form and easily recognized by the help of Ehrenbaum's descriptions and figures in "Nordisches Plankton," Vol. I. Holt gives the spawning period from April to July, and this agrees with the occurrence of the species during the present investigations. The maximum frequency is in July ; distribution is general in the area investigated.

The records of *L. bergylta* Asc. show a similar spawning period with an extension to August. The maximum is in June and July. It is possible that a few individuals of *L. mixtus* may be included in the list, but as the present state of our knowledge with regard to these two forms is extremely limited, the latter has meantime been excluded. The material seems to suggest two forms, one with a clear caudal peduncle region, the other with a slight continuation of the black stellate chromatophores along the ventral margin as indicated in Hefford's newly hatched larva of *L. mixtus*.* These two forms, however, show gradations of pigment.

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* Journ. M.B.A. N.S., Vol. IX, No. 1. 1910.

CARANGIDÆ.

Caranx trachurus L.

TABLE X.

RECORD OF CARANX TRACHURUS L.

No. of Haul.	Date.	Depth.	No.	Size.
XXV. H	10.ix.06	B.	1	13
LXXIX. H	30.vii.08	S.	1	ca. 2·7
CXVIII. H	13.vii.08	M.	1	ca. 4
CXXI. H	20.vii.09	M.	2	4·5–5·5
CXXIV. H	6.viii.09	M.	1	ca. 3
CXXV. H	,,	B.	1	6
CXXX. H	26.viii.09	B.	1	7·7
XXXIX. A	25.vii.13	S.	1	5·95
XLVI. A	29.vii.13	M.	1	16·5
LVII. A	2.viii.13	M	1	10
LVIII. A	,,	S.	1	16·5
LX. A	7.viii.13	S.	1	18·5
LXIV. A	11.viii.13	M.	1	4·489
LXXIX. A	18.viii.13	B.	1	5·36
LXXXVII. A	21.viii.13	M.	1	48
XCV. A	25.viii.13	M.	3	5–6
XCVI. A	,,	B.	1	6
XCVIII. A	,,	M.	1	4·5
XCIX. A	26.viii.13	M.	2	5·5–6·5
C. A	27.viii.13	M.	1	5·226
CII. A	,,	M.	1	6
CV. A	29.viii.13	M.	6	19–26·5
CVII. A	1.ix.13	M.	1	—
CVIII. A	,,	M.	1	7
CXVII. A	5.ix.13	M.	50	ca. 63
CXXIII. A	8.ix.13	M.	3	27–33
CXXIX. A	9.ix.13	S.	1	73
CXXXII. A	11.ix.13	B.	1	80
CXXXV. A	12.ix.13	M.	1	50
CXXXVIII. A	,,	M.	2	46–65
CXLI. A	15.ix.13	B.	2	66–75
CLVI. A	20.ix.13	M.	1	4·5
CLXXI. A	26.ix.13	M.	1	8·576
CLXXII. A	26.ix.13	M.	1	8
CLXXIV. A	,,	B.	1	9·5
CLXXXII. A	30.ix.13.	M.	1	6·5

Caranx trachurus L.

The spawning period of the scad has been given as May and June for the English Channel, but an extension at least to August is warranted by the present records, which indicate June to August. The frequency increases from the twenty-fathom contour line outwards. Young stages with fully developed adult characters were taken in September, generally in midwater or quite close to the surface, at lengths varying from 50 to 80 mm. Several individuals from haul 117 between 60 and 70 mm. in length were kept alive on board the *Oithona,* and transferred to the aquarium tanks. They fed ravenously on small pieces of worms and squid. Measured on 9th February, 1914, six months exactly after transference to the aquarium tanks, they gave measurements ranging from 105 to 130 mm. They had thus almost doubled their length in half a year. Their age may be taken as 9 months, if June be considered the spawning month.

SCOMBRIDÆ.

Scomber scomber L.

Post-larval mackerel were exceedingly few. One hundred and eighteen specimens from 4 to 13 mm. in length were taken during the period of investigation. These occurred during June and July, so that spawning in the neighbourhood must have begun in May in each year. The frequency in numbers is seen to decrease inshore, and to increase from the twenty-fathom line outwards. Previous captures of the same stages (and these are by no means numerous) have been recorded chiefly at considerable distances from land. It is thus highly probable, from the scarcity of individuals in the samples, that the early stages occur in greater numbers much farther out than the area investigated. Subsequent stages have been observed at Plymouth at lengths of about 100 mm. One specimen of 200 mm. was caught in a commercial beam-trawl west of the Eddystone rocks on 11th February, 1914. Scales were developed, which were obviously in their first year's growth, but on considering the length of the fish, the age must be about 1 year 9 months, if, according to Ehrenbaum, scales begin to develop during the second year.

TABLE XI.

Record of Scomber scomber L.

No. of Haul.		Date.	Depth.	No.	Size.
X.	H	20.vi.06	M.	7	5·5–7·3
XI.	H	,,	B.	1	6
XII.	H	,,	S.	2	7–7·5
XIII.	H	,,	M.	4	6–7·5
XIV.	H	,,	B.	4	ca. 7
XV.	H	28.vi.06	S.	6	7–11
XVI.	H	28.vi.06	M.	3	7–7·7
XVII.	H	,,	B.	14	7–10·5
XIX.	H	20.vii.06	S.	1	7
XX.	H	27.vii.06	?	2	4–7·3
XXII.	H	,,	?	3	4–11
LII.	H	10.vi.08	S.	1	7·5
LIX.	H	12.vi.08	S.	6	6–8
LX.	H	,,	B.	1	6
LXI.	H	15.vi.08	B.	2	7–7·5
LXIII.	H	19.vi.08	B.	1	7
LXIV.	H	,,	S.	4	7·5–10
LXV.	H	,,	M.	7	8–9
LXVI.	H	,,	B.	2	ca. 7
LXIX.	H	23.vi.08	S.	2	8–9
LXX.	H	,,	M.	13	4·5–12
LXXI.	H	,,	B.	9	7–10
CI.	H	29.vi.09	S.	3	9·5–11.5
CXVII.	H	13.vii.09	S.	1	ca. 7
CXX.	H	20.vii.09	S.	8	7–9
CXXI.	H	,,	?	3	6·5–7·5
CXXII.	H	,,	?	3	6·5–10
III.	A	11.vi.13	M.	2	4·9–5·04
XVI.	A	19.vi.13	M.	1	11·5
XXXIV.	A	16.vii.13	M.	1	13
XXXIX.	A	25.vii.13	S.	1	9·45

ZEIDÆ.

TABLE XII.

Record of Zeus faber L.

No. of Haul.		Date.	Depth.	No. of Spec.	Size in mm.
LIII.	A	1.viii.13	S.	1	7·5
XCII.	A	25.viii.13	M.	1	5·5
C.	A	27.viii.13	M.	2	9–11·5
CI	A	,,	M.	2	11·5–13·5
CII.	A	,,	M.	1	8
CIII.	A	29.viii.13	M.	1	16
CIV.	A	,,	B.	1	6
CVIII.	A	1.ix.13	M.	2	8–19
CXI.	A	3.ix.13	M.	1	6
CXIII.	A	,,	S.	1	15·5
CXVIII.	A	5.ix.13	M.	1	4·5
CXXV.	A	9.ix.13	M.	1	23
CXXXI.	A	11.ix.13	M.	2	11·5–13
CXXXII.	A	,,	B.	1	11·5
CXXXV.	A	12.ix.13	M.	1	17·5
CLXXVI.	A	26.ix.13	B.	1	7

Zeus faber L.

Our knowledge of the early post-larval stages of the John Dory seems to be restricted to the excellent descriptions of Schmidt in "Medd. fra Komm. for Havund. Serie Fiskeri," Bind II, No. 9, 1908. These post-larvæ ranged from $7\frac{3}{4}$ mm. to 19 mm. in length, and were taken in the English Channel "almost all within the 100-metre curve" from the end of August to the middle of September. My own observations confirm and supplement those of the *Thor*. The series which I have recorded ranges from 4·5 to 23 mm., and all were captured within the twenty and forty fathom contour lines, from the beginning of August to the end of September. Six of these from 4·5 to 7·5 mm. represent younger stages than Schmidt's earliest post-larva of $7\frac{3}{4}$ mm., and I have described and figured two of these, one of 4·5 mm. and one of 6 mm. The remaining fourteen, from 8 to 23 mm., agree in every respect so closely with Schmidt's series that nothing by way of description need be added here.

Fig. 1. Length 4·5 mm.

The maximum height is 2·04 mm., and the length from snout to caudal fin 3·06 mm. The highest point of the body lies directly over the posterior margin of the orbit, and in front of the first dorsal fin. The resemblance in shape to a parallelogram noted by Schmidt for his $7\frac{3}{4}$ mm. post-larva is roughly defined. The angle of the snout is very nearly 90°. The contour of the eye is not quite complete, but, so far as can be judged, its diameter is about equal to the length of the snout. The notochord is straight and extends about $\frac{2}{3}$ along the caudal fin, whose rays are only partially developed. The unpaired fins are still joined to the caudal by a continuance of their fin membranes. The rays of the first dorsal are indistinctly marked. Dorsal and anal interspines are clearly developed, but the fin rays are merely indicated. The ventrals are six-rayed, third largest and sixth shortest. They reach to the middle of the anal fin.

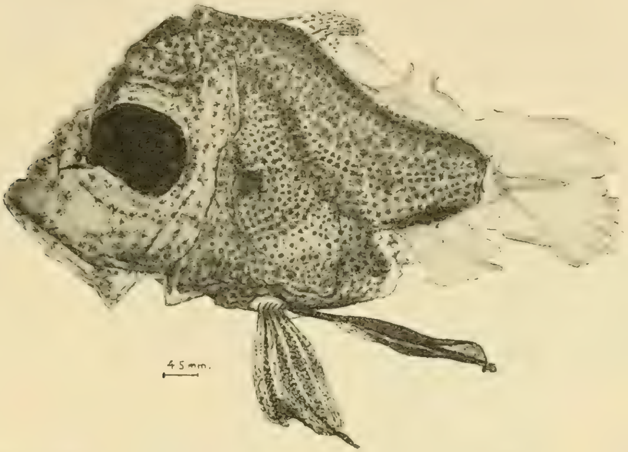

Fig. 1.—*Zeus faber.* Length 4·5 mm. *Oithona* Station, CXVIII. A. 5th Sept., 1913. Total depth 37 fms. Midwater haul.
Del. E. Ford.

The whole surface of the body is covered with large black stellate chromatophores on a greenish background. These are intermingled with smaller chromatophores. The head is not so densely pigmented, and the interspaces between the chromatophores are larger. The ventral fins are densely pigmented with numerous large closely set chromatophores, giving the fins almost a black appearance. The pigment on the first dorsal fin is also evenly distributed, at least on the anterior half. No pigment occurs on the second dorsal, anal, and caudal fins.

Fig. 2. Length 6 mm.

The maximum height is 3·004 mm. and the distance to the caudal 4·78 mm. (to end of body pigment). The highest point of the body is just in front of the first dorsal fin. The angle of the snout is slightly obtuse, and its length about equal to the diameter of the eye, the contour of which is still incompletely defined. The notochord is still straight or perhaps with a very slight upward tendency, caused by the hypural rays of the caudal being more developed. The unpaired fins are now separated from the caudal-fin membrane, and their rays are clearly, though not fully, defined.

The body pigment has spread on to the base of the dorsal and anal interspinous regions. Over the whole surface of the body there is a mixture of large and small stellate chromatophores, and smaller black dots. The unpaired fins are still unpigmented. The anterior half of the first dorsal fin has an aggregate of black chromatophores. The snout region has the least amount of pigment.

The spawning of the dory, according to Cunningham,* takes place during June and July. Hefford† obtained ripe ovarian eggs on 31st August, while Holt‡ observed spent dories in June off the west coast of Ireland. The post-larvæ recorded in the above table suggest a spawning period extending from July to the beginning of September, though it is probable from previous records that spawning may also occur in June.

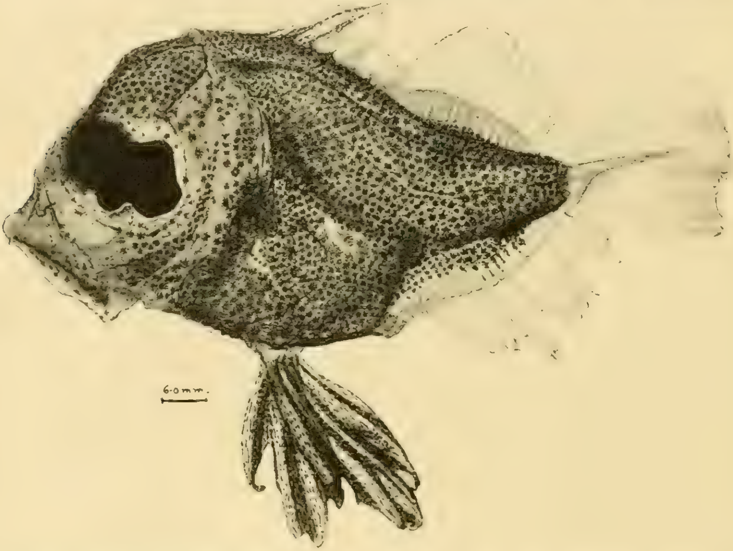

Fig. 2.—*Zeus faber.* Length 6 mm. *Oithona* Station, CXI. A. 3rd Sept., 1913. Total depth 32 fms. Midwater haul.
Del. E. Ford.

Cunningham* worked out the rate of growth of the dory, and gave lengths of about 130 mm. at the end of the first year, and about 280 mm. at the end of two years. The usual length of the dory landed at the Plymouth Barbican is from 15 to 18 inches, which, as Cunningham remarks, "is probably not reached in less than three years." On examining the rings of growth on the opercular and hyomandibular bones (especially on the cerato-hyal), according to Heincke's method,§ I find the results agree with those of Cunningham, though not many specimens were examined. The material was secured by the *Oithona* in the Agassiz and otter trawls.

O Group.	I Group.	II Group.
<150 mm. ..	ca. 150–ca. 250 mm. ..	ca. 250–ca. 350 mm.

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* Jour. M.B.A. N.S., 2. 1891–2.

† Journ. M.B.A. N.S., 9. 1910.

‡ Rep. Roy. Dublin Soc. 1892.

§ Intern. Meeres. Jahresbericht, 4–5.

CAPROIDÆ.

TABLE XIII.

Record of Capros aper L.

No. of Haul.		Date.	Depth.	No. of Spec.	Size in mm.
XCIII.	A	25.viii.13	M.	1	5·5
XCVI.	A	,,	B.	1	5·76
XCVIII.	A	,,	M.	1	3·7
XCIX.	A	26.viii.13	M.	1	4·69
CXVIII.	A	5.ix.13	M.	2	3·4–4
CXXIII.	A	8.ix.13	M.	1	3·5
CLII.	A	19.ix.13	M.	3	3·3–5·5
CLXXIV.	A	26.ix.13	B.	1	6

Capros aper L.

The capture of eleven specimens, 3·3 to 6 mm. in length, of the Cuckoo (as it is known locally in the adult state) between the twenty and forty fathom contour lines within a short radius of the Eddystone rocks, from the end of August to the end of September, helps to add considerably to our knowledge of the early developmental stages of this species. So far as I am aware, only the eggs and resulting larvæ are known through the researches of Cunningham* and Holt,† and one post-larva 15¼ mm. in length described by Schmidt.‡ Thus, between Holt's 2·86 mm. larva and Schmidt's 15¼ mm. post-larva nothing is known. My specimens are all early post-larvæ, but, unfortunately, they are too badly damaged to give a complete descriptive series. However, I have described and figured one of 4 mm. and one of ca. 5 mm. *Zeus faber*, the most nearly allied form, differs so markedly in its post-larval characteristics that there can be no confusing its early stages with those of *C. aper*.

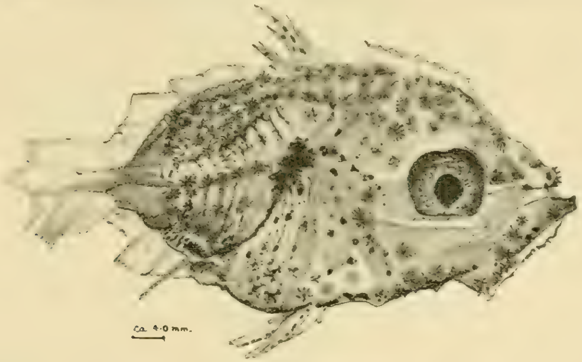

Fig. 3.—*Capros aper*. Length ca. 4 mm. *Oithona* Station, CXVIII. A. 5th Sept., 1913. Total depth 37 fms. Midwater haul.
Del. E. Ford.

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* Journ. M.B.A. N.S., Vol. I. 1889–90.

† Annales du Musée d'Histoire Nat. de Marseille, Tome V, 2.

‡ Medd. fra Komm. for Havund. Serie Fisk., Bind II.

In the latter species, orange-red pigment is already developed in specimens of 4 mm. (on the abdominal region), while a distinct structural feature of Capros post-larvæ is the large number of small spines which cover practically the whole surface of the fish, and appear more markedly round the marginal outline. Two specimens were cleared and mounted. Each had about 22 vertebræ.

Fig. 3. Length 4 mm.

The maximum height, measured along a vertical just in front of the first dorsal and anal fins, is 1·7 mm., and the distance from tip of snout to base of caudal fin is 3·2 mm. The longitudinal axis runs through the middle of the eye. The angle of the snout is very nearly 90°—if anything less: its length is about equal to the longitudinal diameter of the eye, the contour of which is still incomplete. The rhomboidal form of the fish is well marked. Small tooth-like spines are prominent on the snout, chin, and profile of the head. The second dorsal and anal fin rays are just beginning. Hypurals are developed on the caudal. The first dorsal has the spiny rays moderately developed. As yet. the dorsal and anal fins are both joined by a membrane to the caudal. The notochord is straight. Dorsal and anal interspines are developed. The ventral fins are well developed, and reach back almost to the beginning of the anal-fin region. Number of vertebræ ca. 22.

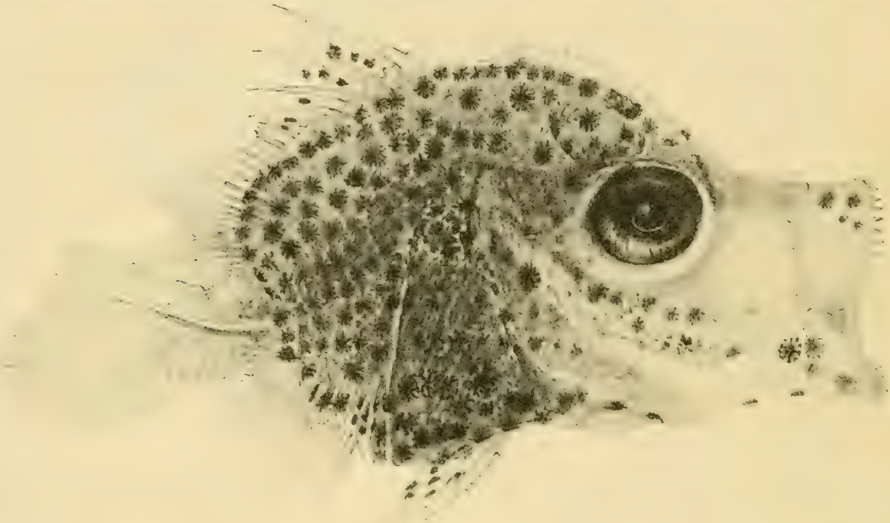

Fig. 4.—*Capros aper.* Length 6 mm. *Oithona* Station, CLII. A. 19th Sept., 1913. Total depth 29 fms. Midwater haul.
Del. E. Ford.

Orange-red pigment, over which occur splashes of bright red, is present on the anterior dorsal half of the abdominal region, while yellow pigment occurs on the rest of the body and very faintly in small patches on the head. A dense aggregate of dark pigment marks off the posterior margin of the abdominal region, beginning just above the longitudinal axis and extending as a line of dark chromatophores to the origin of the anal fin. Large brownish-black stellate chromatophores are spread over the dorsal half of the head and body, leaving a clear space in front of the base of the caudal fin. These large chromatophores are continued across the body post-anally, along the lower part of the abdomen and the ventral margin to the tip of the snout. A few black dots are scattered over the red pigment of the abdominal region. The orbital region, especially the sub-orbital, is practically devoid of pigment. No pigment is visible on the second dorsal, caudal, and anal fins, while a few dark chromatophores appear on the first dorsal and ventral fins.

FIG. 4. LENGTH 6 mm.

The maximum height is contained a little more than twice in the total length: length to caudal fin about $1\frac{1}{6}$ times. The snout is slightly concave above and below as in the adult; its length is about equal to the diameter of the eye. The marginal row of spines in front of the first dorsal fin is very prominent. Similar rows are present on the præmaxillary region and along the spiny ray of the ventral fin. The second dorsal and anal fins are separated from the caudal. Their rays are not fully developed posteriorly. The spines of the first dorsal fin are strong and well developed; nine can be counted. The tip of the notochord is turned upwards and the caudal rays well advanced. The dorsal membrane of the caudal is still fairly large.

The general arrangement and colour of the pigment is much the same as in the previous specimen, though the reddish patch has extended forward on to the orbital region. The colour is generally redder, owing to the presence of a larger number of bright red splashes.

PLEURONECTIDÆ.

Pleuronectes limanda L. (common dab). *P. flesus* L. (flounder). *P. microcephalus* Donov. (merry-sole).

Records of post-larval *P. platessa* are absent from the tables, though the eggs were observed fairly frequently during December, 1913, and January and February, 1914. They appeared in the tow-nets in the latter part of December, 1913, and continued to be observed during

January and February of this year, though less frequently in February. The maximum was in January. The diameters of the eggs varied from 1·809 to 2·07 mm. One newly hatched larva measured about 6·9 mm. These eggs were nearly all secured in inshore areas in Bigbury Bay and off the entrance to the Sound in quite shallow water.

Post-larval dabs are distributed generally over the area investigated, though they occur in greater numbers between the twenty and thirty fathom lines. The flounder shows a higher frequency in inshore areas, while post-larvæ of the merry-sole increase in intensity with the distance from land. The maximum frequency for post-larvæ of the dab lies in May, of the flounder in April and May, and of the merry-sole in June.

A specimen of *P. microcephalus* of 11 mm. shows no sign of metamorphosis, whilst in one of 12·5 mm. metamorphosis has commenced (cf. Kyle,* p. 48, footnote).

PLEURONECTIDÆ.

Sub-fam. BOTHINÆ.

Arnoglossus sp.

An examination of several hundred adult specimens taken in the *Oithona*'s otter trawl in 1913 proves conclusively, with the help of Kyle's work,* the existence of three main species of the genus *Arnoglossus* in the neighbourhood of Plymouth. Kyle relied on four principal features for his segregation of the species, which he classified as :—

(1) Structural Characters.
(2) Dimensional ,,
(3) Numerical ,,
(4) Post-larval Characteristics.

These are sufficiently clear and comprehensive to make the identification of the three species at Plymouth comparatively easy. *A. laterna* Walb. and *A. imperialis* Raf. (*A. lophotes* Günther) occur most abundantly, while *A. thori* Kyle is comparatively rare.

The character of the first few dorsal rays, the length of the head, diameter of eye, and length of ventrals seem quite good enough to separate the three species already noted.

The larval and post-larval material will be reported on more fully in a later communication. There are considerably over a thousand specimens, which represent nearly all the stages up to the metamorphosed condition. A survey of Table 25 shows a maximum frequency in August and September, which, with the records for the earlier months, suggests a prolonged

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* Rept. Danish Ocean. Exped., 1908–10. No. 2 (1913).

PLEURONECTIDÆ.

TABLE XIV.

RECORD OF PLEURONECTES SP.

			P. limanda.		P. flesus.		P. microcephalus.	
No. of Haul.	Date.	Depth.	No.	Size.	No.	Size.	No.	Size.
I. H	10.v.06	B.	3	14·5–15	—	—	—	—
II. H	22.v.06	S.	—	—	6	7–9	—	—
III. H	22.v.06	M.	1	10	7	7–9	—	—
IV. H	22.v.06	B.	6	6–9	16	7–8·5	6	8
V. H	,,	B.	4	10–12	6	5·5–9	—	—
VI. H	30.v.06	B.	26	6·5–10	—	—	—	—
VIII. H	,,	B.	—	—	24	8–11·5	—	—
XI. H	20.vi.06	B.	1	13·5	—	—	—	—
XIII. H	,,	M.	6	6–10·5	—	—	—	—
XIV. H	,,	B.	—	—	—	—	3	12–14
XVII. H	28.vi.06	B.	5	7·5	—	—	1	8·5
XXXI. H	25.iii.07	S.	—	—	7	3·5–8	1	6
XXXII. H	,,	M.	—	—	1	5	—	—
XXXIII. H	11.iv.07	M.	8	6–7	15	4–7	—	—
XXXIV. H	,,	B.	3	9	20	4·5–9	—	—
XXXV. H	6.vi.07	B.	—	—	—	—	2	6–9
XXXVII. H	,,	S.	—	—	—	—	1	10·5
XLII. H	28.v.08	?	1	12	—	—	—	—
XLIV. H	,,	?	16	7·5–13	—	—	11	9–13
XLVII. H	1.vi.08	B.	1	10·4	—	—	—	—
XLIX. H	,,	M.	2	12·5–13	—	—	—	—
L. H	,,	B.	1	13	—	—	3	ca. 8
? LII. H	4.vi.08	?	—	—	2	8–10	—	—
LIII. H	,,	S.	—	—	—	—	2	7·5–11
LIV. H	,,	M.	—	—	1	8	—	—
LV. H	5.vi.08	S.	—	—	—	—	1	7
LVI. H	,,	B.	1	13	—	—	—	—
LX. H	12.vi.08	B.	—	—	—	—	1	8
LXVI. H	19.vi.08	B.	—	—	—	—	6	7–16
LXIX. H	23.vi.08	S.	—	—	—	—	1	7
LXX. H	,,	M.	—	—	—	—	1	8·7
LXXI. H	,,	B.	—	—	—	—	2	7–8
LXXIV. H	30.vi.08	B.	1	8	—	—	5	6–8
LXXV. H	,,	B.	—	—	—	—	9	5–8
XCV. H	28.iv.09	S.	—	—	3	7–8	—	—
XCVI. H	,,	B.	—	—	28	8–9	—	—
XCVII. H	3.v.09	?	—	—	2	10	—	—
XCVIII. H	7.v.09	?	—	—	4	9–10	—	—
XCIX. H	13.v.09	M.	12	8–12	—	—	—	—
C. H	24.v.09	S.	—	—	1	8	—	—
CIV. H	2.vi.09	B.	3	8–12	—	—	—	—
CIX. H	25.vi.09	S.	—	—	1	9	—	—
CXVII. H	13.vii.09	S.	—	—	—	—	1	7
I. A	6.vi.13	S.	—	—	3	7–9·31	—	—
II. A	,,	B.	2	6	—	—	2	6·96–7
III. A	11.vi.13	M.	—	—	3	7	9	—
V. A	12.vi.13	M.	1	1·59	—	—	14	7·5–11
VI. A	13.vi.13	M.	—	—	—	—	4	7–8·5
IX. A	,,	B.	—	—	5	7·4–8·54	—	—
X. A	16.vi.13	M.	4	7–10·15	1	8·75	3	7·7–9·17
XIII. A	18.vi.13	M.	2	10·5–11·5	—	—	—	—
XV. A	,,	M.	2	11·06-11·34	—	—	1	9·5
XXIII. A	30.vi.13	B.	1	5·39	—	—	1	6
XXIV. A	3.vii.13	M.	—	—	—	—	2	9·5–10
XXXVII. A	24.vii.13	B.	—	—	—	—	1	12·5
XLIII. A	28.vii.13	S.	3	39–42	—	—	—	—

spawning period for the three species. Kyle has noted an indefinitely prolonged spawning period for *A. thori* and for *A. laterna*, and has suggested a similar period for *A. imperialis*, although he states that the main spawning period for this last species lies in spring. The occurrence of a large number of larval and early post-larval forms of *A. imperialis*, in August and September, 1913, appears to confirm the view of an extended spawning period.

The frequency of the three species is highest off-shore between the twenty and forty fathom lines, and decidedly low within the twenty-fathom line—the captures inside this limit being confined to four specimens, 6 to 16 mm. in length, from hauls 70 A and 73 A.

It is interesting to note the occurrence in the collection of the pale North Sea and English Channel post-larval form of *A. laterna*, and the dark Bay of Biscay form of the same species. These two varieties of post-larvæ have been fully described by Kyle, who has suggested a higher number of vertebræ for the more southern form.

Sub-fam. RHOMBINÆ.

Rhombus maximus Will. *R. lævis* Rond.

The few records of these two species indicate an earlier spawning for the brill. Seven of the eight individuals recorded were taken beyond the twenty-fathom line. Permanent bottom stages of the turbot were secured with a push-net in Whitsand Bay on October 1st, 1913. These measured from 25–38 mm. (1″ to 1½″) in length, and had fully assumed the adult condition. On the same date, brill of 130–140 mm. (5″ to 5½″) in length were secured in the otter trawl in 3 to 5 fathoms in the same locality. These were probably a little over a year old.

TABLE XV.

RECORD OF RHOMBUS SP.

No. of Haul.		Date.	Depth.	R. maximus.		R. lævis.	
				No.	Size.	No.	Size.
XXXIX.	A	25.vii.13	S.	—	—	1	5·25
LXXXI.	A	19.viii.13	B.	—	—	1	6·5
CV.	A	29.viii.13	M.	—	—	1	5·5
CXVIII.	A	5.ix.13	M.	—	—	2	3·5–4·2
CXXXVIII.	A	12.ix.13	M.	1	7	—	—
CXL.	A	15.ix.13	M.	1	7·3	—	—
CXLII.	A	15.ix.13	B.	1	7	—	—

Sub-fam. RHOMBINÆ.

Scophthalmus norvegicus Gthr. *S. unimaculatus* Bnp.
Zeugopterus punctatus Bl.

Scophthalmus norvegicus Gthr.

This is the commonest topknot of the district. The records of the pelagic stages in Table 25 indicate an indefinitely prolonged spawning period from March or April to July. The maximum for the post-larvæ lies in June, so that the densest spawning month is most probably May. Frequency is highest between the twenty and thirty fathom lines, and lowest beyond the thirty-fathom line.

TABLE XVI.

RECORD OF SCOPHTHALMUS UNIMACULATUS BNP.

No. of Haul.		Date.	Depth.	No.	Size.
XI.	A	16.vi.13	B.	1	7·5
XXIII.	A	30.vi.13	B.	1	7·98
XXXII.	A	15.vii.13	B.	1	11

The adult one-spotted topknots are of exceedingly rare occurrence at Plymouth, so that the capture of these three post-larvæ is all the more interesting. They were all secured beyond the twenty-fathom line, from 16th June to 15th July, and were identified with the help of Petersen's descriptions and figures of specimens, ranging from 6·7 to 8 mm. in length.

The oldest stage has a length of 11 mm., and it is still perfectly symmetrical. The concavity of the snout is well marked, and the dorsal fin is almost on a level with the posterior margin of the orbit. The diameter of the eye is contained about three times in the snout length. Ventrals are developed, though still small. The caudal fin is rounded and almost fully developed and about seventeen rays can be counted. The two pairs of otocyst spines are quite conspicuous, though not so prominent as in *Z. punctatus*.

Small dendritic chromatophores are scattered over the head and body, much as in *S. norvegicus*, though practically absent from the orbital region, and less dense on the interspinous region. There is a suggestion of the pigment on the unpaired fins beginning to concentrate into bars.

TABLE XVII.

Record of Zeugopterus punctatus Bloch.

No. of Haul		Date.	Depth.	No.	Size.
IV.	H	22.v.06	B.	1	6
V.	H	,,	B.	1	7
VIII.	H	30.v.06	B.	6	ca. 11
XIV.	H	20.vi.06	B.	1	9
XXXIII.	H	11.iv.07	M.	12	5–6
XXXIV.	H	,,	B.	3	3–5
XXXV.	H	6.vi.07	B.	2	6–9
XLIV.	H	18.v.08	B.	2	7–7·5
LXVI.	H	19.vi.08	B.	1	9
XCV.	H	28.iv.09	S.	1	4
CIII.	H	2.vi.09	M.	1	7·5
CX.	H	10.vi.09	M.	1	9
I.	A	6.vi.13	S.	10	6·5–8.5
III.	A	11.vi.13	M.	2	ca. 5·5
VI.	A	13.vi.13	M.	1	6·3
XI.	A	16.vi.13	B.	1	11·69
XV.	A	18.vi.13	M.	2	8–8·5

Zeugopterus punctatus Bl.

Post-larvæ occurred from April to June, with their maximum in June. The spawning period probably extends from March to May for the Plymouth area. Hefford gives middle of February to May. Their distribution is general, though there is a much higher frequency under ten fathoms and between the twenty and thirty fathom lines.

Sub-fam. SOLEINÆ.

TABLE XVIII.

Record of Solea.

No. of Haul.		Date.	Depth.	S. vulgaris.		S. variegata.		S. lutea.		S. lascaris.	
				No.	Size. mm.	No.	Size. mm.	No.	Size. mm.	No.	Size. mm.
I.	H	10.v.06	B.	1	10·5	—	—	—	—	—	—
IV.	H	22.v.06	B.	2	4	72	6	—	—	—	—
VI.	H	30.v.06	B.	—	—	6	6	—	—	—	—
VIII.	H	,,	B.	1	9	—	—	—	—	—	—
XIII.	H	20.vi.06	M.	—	—	2	4·2	—	—	—	—
XIV.	H	,,	B.	—	—	1	6	—	—	—	—
XVII.	H	28.vi.06	B.	—	—	5	4–8	—	—	—	—
XLIV.	H	28.v.08	B.	—	—	1	5·5	—	—	—	—
LIII.	H	4.vi.08	S.	—	—	2	3·5–5·5	—	—	—	—
LVIII.	H	10.vi.08	B.	—	—	3	3–5·5	—	—	—	—
LIX.	H	12.vi.08	S.	—	—	2	4–5	—	—	—	—
LX.	H	,,	B.	—	—	5	4–7	—	—	—	—
LXI.	H	15.vi.08	B.	—	—	2	5–6	—	—	—	—
LXV.	H	19.vi.08	M.	—	—	14	3·2–7	—	—	—	—
LXVI.	H	,,	B.	—	—	5	7–8	—	—	—	—
LXVII.	H	,,	S.	—	—	1	4	—	—	—	—
LXIX.	H	23.vi.08	S.	—	—	16	4–6	—	—	—	—
LXX.	H	,,	M.	—	—	49	4·5–9	—	—	—	—
LXXI.	H	,,	B.	—	—	8	5–7	—	—	—	—
LXXVI.	H	2.vii.08	M.	—	—	—	—	1	4	—	—
LXXIX.	H	15.vii.08	B.	—	—	1	10	3	4·8–6	—	—
XCII.	H	20.viii.08	B.	—	—	—	—	1	6	—	—
XCVII.	H	3.v.09	?	4	4·2–5	—	—	—	—	—	—

TABLE XVIII.—*Continued.*

RECORD OF SOLEA.

No. of Haul.		Date.	Depth.	S. vulgaris.		S. variegata.		S. lutea.		S. lascaris.	
				No.	Size. mm.	No.	Size mm.	No.	Size. mm.	No.	Size. mm.
CI.	H	24.v.09	B.	1	7·5	—	—	—	—	—	—
CIII.	H	2.vi.09	M.	1	5	—	—	—	—	—	—
CIV.	H	,,	B.	1	6	—	—	—	—	—	—
CXVII.	H	13.vii.09	S.	—	—	1	4·5	—	—	—	—
CXXII.	H	20.vii.09	B.	—	—	2	5·3–10	—	—	—	—
CXXIV.	H	6.viii.09	M.	—	—	1	5	—	—	—	—
CXXV.	H	,,	B.	—	—	2	6–7	—	—	—	—
CXXXI.	H	27.viii.09	M.	—	—	2	ca. 4	—	—	—	—
I.	A	6.vi.13	S.	—	—	—	—	1	4·55	—	—
II.	A	,,	B.	1	6·86	—	—	3	3·7–5·8	—	—
III.	A	11.vi.13	M.	—	—	24	3·9–6·5	—	—	—	—
V.	A	12.vi.13	M.	—	—	2	5·1–6·1	2	3·85–4·9	—	—
VI.	A	13.vi.13	M.	1	8·75	—	—	1	6·51	—	—
XII.	A	18.vi.13	S.	—	—	1	8	—	—	—	—
XIV.	A	,,	B.	—	—	2	6·95–11	—	—	—	—
XV.	A	,,	M.	—	—	1	7·49	—	—	—	—
XVI.	A	19.vi.13	M.	—	—	—	—	2	5–7·35	—	—
XVII.	A	,,	M.	—	—	—	—	2	4·2	—	—
XX.	A	20.vi.13	S.	—	—	3	5–6·3	—	—	—	—
XXII.	A	27.vi.13	M.	—	—	4	4·13–7	1	4·5	—	—
XXIII.	A	30.vi.13	B.	—	—	3	5·25–7	—	—	—	—
XXXIX.	A	25.vii.13	S.	—	—	—	—	—	—	1	5·025
XCVI.	A	25.viii.13	B.	—	—	2	8–8·5	—	—	—	—
XCVIII.	A	,,	M.	—	—	—	—	—	—	3	6–9·5
C.	A	27.viii.13	M.	—	—	—	—	—	—	1	8
CII.	A	,,	M.	—	—	—	—	—	—	1	10·5
CIV.	A	29.viii.13	B.	—	—	—	—	—	—	1	damaged
CX.	A	1.ix.13	B.	—	—	—	—	—	—	1	8·5
CXX.	A	8.ix.13	M.	—	—	—	—	—	—	1	8·7
CXXIII.	A	,,	M.	—	—	—	—	—	—	1	4·5
CXXV.	A	9.ix.13	M.	—	—	—	—	—	—	1	11
CXXX.	A	10.ix.13	M.	—	—	—	—	—	—	1	4·69
CLV.	A	20.ix.13	B.	—	—	—	—	—	—	1	7·5
CLIX.	A	22.ix.13	B.	—	—	—	—	—	—	1	11·25
CLXI.	A	,,	M.	—	—	—	—	—	—	1	4
CLXIII.	A	24.ix.13	M.	—	—	—	—	—	—	2	7–10·5
CLXIX.	A	25.ix.13	M.	—	—	—	—	—	—	1	5·5
CLXXI.	A	26.ix.13	M.	—	—	—	—	—	—	1	5·786
CLXXII.	A	,,	M.	—	—	—	—	—	—	1	7·75
CLXXIII.	A	,,	B.	—	—	—	—	—	—	1	11·5
CLXXXII.	A	30.ix.13	M.	—	—	—	—	—	—	3	7·5–11·5

Solea vulgaris Quensel. *S. variegata* Don. *S. lutea* Risso.
S. lascaris Risso.

Four species of soles are found in the neighbourhood, and all are represented in the post-larval material from the early post-larva up to the metamorphosing stage.

These are : *S. vulgaris* Quens. Common sole.
S. variegata Don. Thickback.
S. lutea Risso. Solenette.
S. lascaris Risso. Sand-sole.

With a post-larval series of each, specific determination has been comparatively easy. Of the four species, *S. variegata* (thickback) occurs most frequently. The maximum number of post-larvæ was in June. They were taken in diminishing numbers on to August. This coincides with the period recorded by Petersen for the capture of his post-larval specimens—May to July. Records of *S. lutea* are confined to July and August, but the number of individuals is extremely small. *S. lascaris* occurred in increasing numbers from July to September, after which month they disappeared from the pelagic hauls. *S. vulgaris* post-larvæ were taken in May and June, but were extremely few, and by no means representative of the number of individuals in the neighbourhood. *S. vulgaris* and *S. lutea* show a higher frequency inshore at depths of about ten fathoms or less, while *S. variegata* and *S. lascaris* have a distinctly low frequency for this area. The maximum for these two species lies between the twenty and thirty fathom lines. Both were taken beyond the thirty-fathom line, and it is possible, at least for *S. variegata*, that the frequency may increase with the distance from land. Our knowledge of the life-history and developmental stages of *S. vulgaris* and *S. lutea* is fairly complete. Kyle has remarked on the greater breadth of similar forms of *S. lutea* from the more southern waters to those from the North Sea. My specimens of *S. lutea* show a distinct gradation from the one to the other. The greatest breadth (without the dorsal fin) ranges from about 25% to slightly over 40% of the total length.

S. variegata Don.

Post-larval *S. variegata* are known chiefly from the researches of Petersen,* whose specimens were captured mostly over depths from 1000 to 4000 metres, though he recorded captures from 53 and 113 metres. The series ranged from 7 to 18·3 mm. in length. At the latter length, metamorphosis was a long way off completion. It seems peculiar that my specimens are equally well advanced in development, but at a much smaller size. My post-larvæ of almost 4 mm. are closely identical with Petersen's 7 mm. post-larva, and just as far advanced in development. At 11 mm. in my material metamorphosis has already reached almost half-way. There is at a length of 11 mm., the largest post-larva in my collection, a distinctive difference in pigmentation from Petersen's metamorphosed specimen. The pigment is not confined to the fins, interspines, and margin of the abdomen and head, but also scattered universally over the whole of the body, not as tiny black dots, but as fairly stout stellate chromatophores of moderate size.

* Medd. fra Komm. f. Havund. Serie Fisk. Bind III, Nr. 1. 1909.

As Kyle* has remarked on his single specimen of 7 mm., the depth of body is considerable. This is also a characteristic feature in nearly all my specimens, and contrasts with the much narrower body of Petersen's post-larvæ. There is the further difference to be considered in the localities of the two captures. The area of maximum intensity of this species in the region investigated at Plymouth lies between the twenty and thirty fathom lines, at no great distance from land, whereas Petersen secured his specimens at considerable distances off-shore, and over much greater depths.

The numerical characters of my specimens certainly agree with those of *S. variegata.* D 71–72,
A 56–57,
Vertebræ 9 (10)+29 (30) (31).
Petersen gave for his post-larvæ D 71–76,
A 46–60
Vertebræ 9 (10)+29 (30) (31) (32).
Kyle's single specimen of 7 mm. had 10+30 vertebræ.

Structural and post-larval characteristics are much the same in my specimens as in Petersen's, except for those few characters noted above. There is no trace of an air bladder nor of barred pigment. Holt and Byrne have noted this barred pigmentation for the transition stage, and Mr. Byrne has kindly supplied me with a note on a specimen 16 mm. long (without caudal) having the general appearance of the adult. It was taken 50 miles W.N.W. of Cleggan Head, at a depth of about 120 fathoms. The youngest specimen with the adult appearance which I have observed at Plymouth measured 45 mm. Further investigation is required, especially in the later metamorphosing stages, to arrive at a fuller knowledge of this species.

S. lascaris Risso. (Sand-sole.)

Our knowledge of the post-larval development of the sand-sole is extremely limited. It is confined practically to two specimens, one of 8 mm., described by Kyle in "Rep. of the Danish Oceanographical Expeditions, 1908–10, No. 2"; the other of 11 mm., described by Cunningham as a metamorphosing stage of *S. vulgaris* or *S. lascaris* in *Journal M.B.A.*, 1897–99. Ehrenbaum was the first to attribute this latter specimen definitely to *S. lascaris*, and, from the material at my disposal, there is no doubt about his identification being correct.

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* Report Dan. Ocean. Exped., 1908–10. No. 2. 1913.

Several adult *S. lascaris* have been trawled from time to time, principally in Whitsand Bay, and I have thought it worth while to give a record of their numerical characters. Nine of these specimens were cut up and the vertebræ counted. In the other eleven individuals the fin formula alone has been recorded.

NUMERICAL CHARACTERS OF ADULTS.

1	80	65	46
2	90	76	48
3	85	70	46
4	87	69	46
5	87	71	47
6	86	70	46
7	81	66	47
8	83	67	48
9	88	72	46
10	80	67	—
11	86	70	—
12	86	69	—
13	91	73	—
14	84	69	—
15	82	71	—
16	85	69	—
17	85	71	—
18	87	73	—
19	91	73	—
20	82	68	—

Summary for 20 specimens :—

	D 80–91	A 65–76	Vertebræ 46–48
Kyle gives	D 79–89	A 61–70	Vertebræ 47–48

My post-larvæ give the following range :—

D 89–96	A 68–76	Vertebræ ca. 47

There is thus an extension to Kyle's summary, which works out as follows :—

D 79–96
A 61–76
Vertebræ 46–48

This large amount of variation seems to be a characteristic feature in the genus Solea.

From previous records of the eggs of this species, and from the occurrence of the post-larval forms, spawning seems to take place during June, July, and August. Hefford recorded the capture of one egg in March, the resulting larva of which he described and figured.* Holt† obtained the newly hatched larva at a length of 4·1 mm., but its appearance was entirely different from Hefford's specimen. The distinguishing feature was a well-marked pre-cephalic expansion of the dorsal fin membrane. It was taken much later in the year, and thus more in agreement with the known spawning period than Hefford's larva. My earliest post-larvæ have all got this peculiar "hooded" structure, though much less pronounced. There is distinct evidence in my specimens of shrinkage in this region, so that there seems to be grounds for believing that this pre-cephalic structure was indeed larger in the larval state. I am inclined to consider Hefford's larva, though not without great reservation, as belonging to another species, possibly *S. variegata*. The pigmentation, shape of head, depth of body, more backward position of the anus, and length of the specimen seem to agree more nearly with the characters of *S. variegata*. I have described and figured post-larval stages from 5·025 to 11·25 mm. The rate of growth seems rather unequal, and considerable variation is apparent. The metamorphosed specimen of 11·25 mm., though far from having completed its post-larval growth, represents perhaps the minimum length for such an advanced stage, as in specimens of 11·5 mm., the left eye has not even reached the dorsal margin.

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* Journ. M.B.A. Vol. IX. 1910.

† Sci. Trans. Roy. Soc. Dublin. Vol. IV, S. 2. 1891.

S. lascaris Risso.

FIG. 5. LENGTH 5·025 mm.

Length 5·025 mm., of which 3·4 mm. are post-anal. The preanal length is about $2\frac{1}{2}$ times in the total, so that the anus is well in front of the middle of the body. The snout is slightly longer than the diameter of the eye. The lower jaw projects beyond the upper. The greatest depth, which is measured over the middle of the abdominal region, is slightly under three times in the total length. The development of the fin rays is suggested posteriorly by the arrangement of the dorsal and anal pigment. Hypural rays are developed. The vertebræ have not advanced sufficiently to be counted. The snout is compressed and notched where it receives the dorsal fin membrane. The membrane curves back half-way over the nasal region and parallel to it, and then rises almost vertically, giving the larva a "hooded" appearance. This feature is quite distinctive of *S. lascaris*, and reminds one of Holt's newly hatched (4·1 mm.) larva of the same species with its "abnormal" development of this region. The mid-brain is prominent; it overlies the orbit and its anterior outline is almost parallel to the anterior dorsal fin margin. The eyes are perfectly symmetrical. There is a distinct suggestion of an air bladder in a curved line of dark pigment lying on the middle of the dorsal margin of the abdominal region. As yet, there is no appearance of interspines. The notochord is straight or nearly so. The pectorals are fairly large, and equally developed.

The pigmentation is striking, and quite distinctive. The head, body, and abdomen are covered with large, exceedingly delicate stellate chromatophores, which assume a faint bronze tint in formalin. These are largest on the abdominal region. A few dark stellate chromatophores are present on the dorsal surface of the brain region. On the dorsal fin membrane, and similarly on the anal, there is a large aggregation of these chromatophores posteriorly, which assume a pronounced bar formation. On the dorsal fin also are two large much darker chromatophores, which stand out clearly from the rest of the pigment—one is situated over the beginning of the notochord, the other about half-way along the fin. A few delicate chromatophores are present on the anterior expansion of the dorsal fin membrane, and near the large mid-dorsal chromatophore. The caudal is sparsely pigmented. Several chromatophores are scattered over the anal fin in front of the posterior bar, while a row of small dark chromatophores extends along the margin of the abdomen to the tip of the snout. The dark curve of the air bladder has already been mentioned. There are extensions in front towards the eye, and behind as far as the downward curve of the intestine. An interrupted line of pigment runs from behind the eye, on a level with its dorsal margin, for a considerable distance along the notochord.

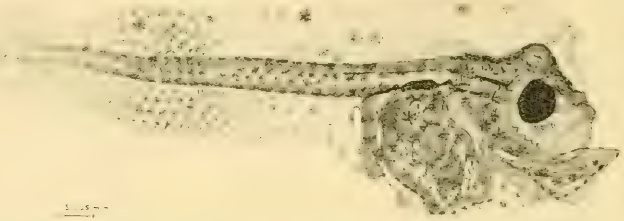

FIG. 5.—*Solea lascaris*. Length 5·025 mm. *Oithona* Station, XXXIX. A. 25th July, 1913. Total depth 25 fms. Surface haul.
Del. E. Ford.

FIG. 6. LENGTH 6 mm.

The preanal length is considerably less than half the total length. The snout is slightly larger than the diameter of the eye. The fin formula cannot be counted, at least dorsally, though the anal fin rays are much farther advanced. The vertebræ number about 9+38=47. The lower jaw still projects. The snout is decidedly more vertical and almost continuous in outline with the dorsal fin margin, except for a small indentation marking the origin of the dorsal fin. The dorsal fin protuberance is almost parallel with the margin of the mid brain, the anterior border of which is in advance of the orbit. The eyes are symmetrical. Interspines have developed. The first dorsal interspine lies directly over the middle of the medullary region. The air bladder is now well defined and is comparatively large—its length being almost equal to that of the snout. The notochord is still straight.

The pigment is much more pronounced, though similar in arrangement to that in the previous specimen. Chromatophores are developed on the snout and on the brain region, which latter is distinctly marked by a line of dark pigment, stretching from the fore brain, over the mid brain, hind brain and medulla, and ending with the beginning of the notochord. The notochordal line of pigment is less interrupted, and reaches almost to the caudal. This line of pigment marks out the ventral aspect of the spinal chord. An interrupted line of pigment runs along the base of the anal interspines, becoming more distinct in the region of the posterior bar of pigment.

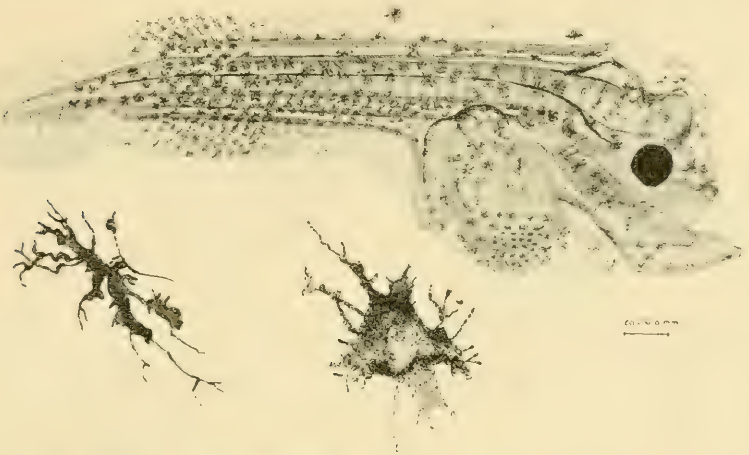

FIG. 6.—*Solea lascaris*. Length ca. 6 mm. *Oithona* Station, XCVIII. A. 25th Aug., 1913. Total depth 36 fms. Midwater haul.
FIG. 6a.—Chromatophores enlarged.
Del. E Ford.

FIG. 7. LENGTH 7·75 mm.

The preanal length is 3·42 mm. The snout (measured from the tip of the upper jaw to the anterior margin of the eye) is about equal to the diameter of the eye. The dorsal and anal fin rays have advanced considerably and stretch half-way across the fin membranes, though not sufficiently clear on the distal portions of the fins to be counted with accuracy. Vertebræ number approximately 9+37. The notch in front of the origin of the dorsal fin is much more conspicuous. It overlies the region of the mid brain. The interspines have extended forwards. The tip of the notochord is bent upwards, and the caudal rays are developed : twelve rays can be counted.

A few stellate chromatophores have collected round the two large separate dorsal fin chromatophores at positions corresponding to the future pigment bars. The first anal bar is also suggested by an aggregation of similar chromatophores at the beginning of the anal fin.

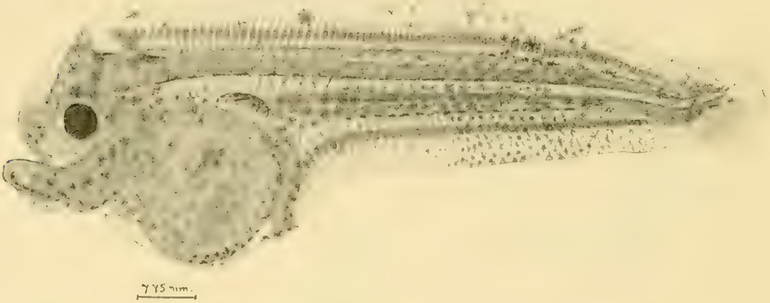

FIG. 7.—*Solea lascaris.* Length 7·75 mm. *Oithona* Station, CLXXII. A. 26th Sept., 1913. Total depth 27 fms. Midwater haul.
Del. E. Ford.

FIG. 8. LENGTH 8·7 mm.

Length 8·7 mm., of which 5·69 mm. are post-anal. The anus is thus well in front of the middle line. Length of snout ca. ·5 mm. (measured from tip of upper jaw) ; diameter of eye ca. ·4 mm. The greatest depth is slightly more than the preanal length. Length of air bladder about equal to snout length.

Fin formula D ca. 89.
A ca. 73.
Vertebræ 9+ca. 38=ca. 47.

The snout is more rounded and swollen anteriorly, and extends backwards to the origin of the dorsal fin membrane, which projects as a small knob in front and above the mid brain, the anterior margin of which is in line with that of the orbit. The dorsal interspines have advanced to a level with a vertical line through the middle of the eye, and are well developed. The lower jaw still projects a little, and the mouth has a downward curve. The eyes are symmetrical. The tip of the notochord is bent upwards, and the caudal rays are almost fully developed.

The general appearance of pigment is very much the same as in the last specimen. There are now three distinct barred regions in the dorsal fin and two in the anal. The median dorsal bar lies exactly opposite the anterior anal bar, while the posterior dorsal bar seems to be continued across the body on to the anal fin. The two large separate dorsal fin chromatophores have disappeared, and their place is occupied with the median and anterior aggregates of chromatophores. Distinct dashes of black pigment are present along the bases of the interspines dorso-ventrally, but fewer in number and of larger size dorsally. Black dots occur on the chin, along the abdominal margin and on the anal fin, but these are obviously the centres of extremely delicate stellate chromatophores. The caudal fin is weakly pigmented—a few chromatophores occurring near the base and along the lower rays. The specimen is equally pigmented on both sides.

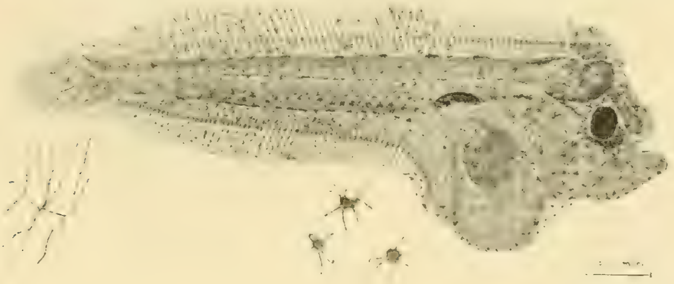

FIG. 8.—*Solea lascaris.* Length 8·7 mm. *Oithona* Station, CXX. A. 8th Sept., 1913. Total depth 25 fms. Midwater haul.
FIG. 8a.—Chromatophores enlarged.
Del. E. Ford.

FIG. 9. LENGTH 9·5 mm.

The snout is larger than the diameter of the eye by about $\frac{1}{5}$. The greatest depth is slightly more than the preanal length.

Fin formula D ca. 89.
A ca. 71.
Vertebræ 9+ca. 38=ca. 47.

The concavity of the snout and dorsal fin membrane is clearly V-shaped. The mid brain has receded and on a level with the last third of the orbit. The eyes are still symmetrical. The lower jaw is practically on a level with the upper, but the chin projects, while the curve of the mouth is even more pronounced than in the previous specimen. The dorsal interspines have reached beyond the mid brain, and in line with a vertical through the middle of the orbit.

The pigment is much as in the previous specimen, with the barred areas forming a distinct feature. The spinal chord is marked out above and below by a continuous row of small dashes, while across the base of the caudal fin the chromatophores appear to be arranged into another small transverse bar.

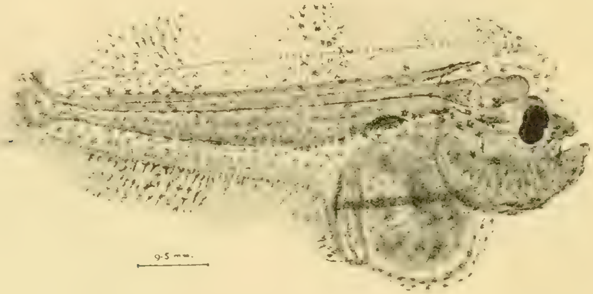

Fig. 9.—*Solea lascaris.* Length 9·5 mm. *Oithona* Station, XCVIII. A. 25th Aug., 1913. Total depth 36 fms. Midwater haul.
Del. E. Ford.

Length 10·0 mm. The preanal and post-anal lengths show the same proportion as in the previous specimens. The snout is also longer than the diameter of the eye.

Fin formula D 89.
A 71.
Vertebræ 9+38=47.

The concavity of the snout is still well marked, though not quite so markedly V-shaped. The left eye has begun to migrate. The interspines have advanced beyond the vertical from the anterior margin of the left orbit, which is slightly in front of the right. The brain has receded, and the anterior margin of the mid brain overlies the middle of the right eye.

There is practically no difference in pigmentation from the last specimen.

Fig. 10. Length 11 mm.

Metamorphosis has gone a stage farther. The left eye is almost clear of the right, but has not yet reached the dorsal surface. The snout is more or less "hooked," with the lower arm of the V-shaped concavity almost horizontal, round which the left eye will undoubtedly travel. The abdomen is beginning to get enclosed.

Fin formula D 89.
A ca. 68.
Vertebræ 9+38=47.

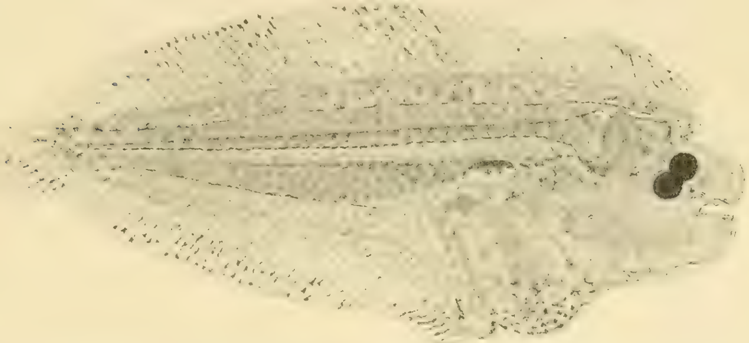

FIG. 10.—*Solea lascaris.* Length 11 mm. *Oithona* Station, CXXV. A. 9th Sept., 1913. Total depth 25 fms. Midwater haul.
Del. E. Ford.

Large exceedingly delicate stellate chromatophores are diffusely scattered over the head, body, and abdomen. The dorsal and anal fins retain the darker barred aggregates, while a similar bar is present on the base of the caudal fin, the posterior half of which is devoid of pigment.

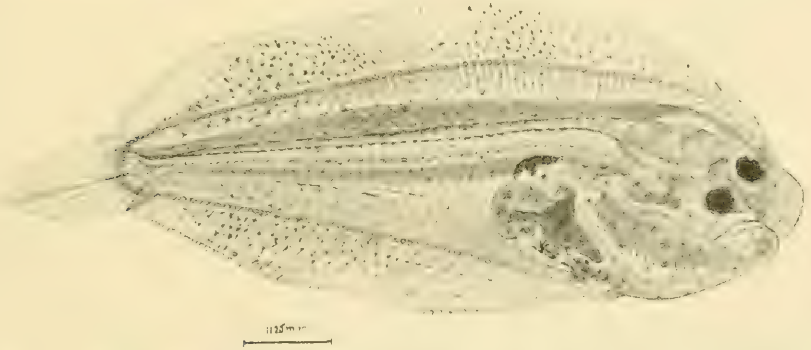

FIG. 11.—*Solea lascaris.* Length 11·25 mm. *Oithona* Station, CLIX. A. 22nd Sept., 1913. Total depth 27 fms. Bottom haul.
Del. E. Ford.

FIG. 11. LENGTH 11·25 mm.

Length 11·25 mm., of which 8·5 mm. are post-anal. The preanal length has considerably lessened. The left eye is almost wholly in advance of the right, which is contained about twice in the snout length (reckoned from tip of snout to margin of right eye).

Fin formula D ca. 96.
A ca. 76.
Vertebræ 9+37 (38)=46 (47).

The upper lip on the right side is curved as in the adult. Teeth are not developed on the right side, though present in the lower jaw on the future blind side. Both eyes are on the right side, and the dorsal fin has grown forward on to the middle of the snout so that the concavity has been overgrown. The abdominal region is entirely enclosed. The ventrals are equally developed, and reach almost to the first anal ray. There is still no trace of the large fringed nostril on the blind side. The air bladder is rather large.

The pigmentation agrees closely with the preceding stages. Both sides are equally pigmented, so that the permanent bottom stage has not quite been reached. The small dark chromatophores which are present on the abdominal margin of the previous stages have now collected into a dense aggregate over the anus. Stellate chromatophores are universally distributed, and extremely delicate, having a rusty-brown appearance. The three dorsal and two anal bars are still quite distinct, while the smaller bar across the base of the caudal has practically disappeared.

This stage is much farther advanced than Cunningham's 11 mm. post-larva. There are six more dorsal rays; the abdomen is enclosed and ventrals are developed. The rough saw-like margins of the dorsal and anal fins are quite typical, and the rays in my specimen reach the tip of each tooth.

GOBIIDÆ.

Gobius minutus Pall. *G. microps* Kr. *G. scorpioides* Coll. *Crystallogobius nilssoni* Düb. and Kör. *Aphya pellucida* Nardo.

Table 25 gives a record of the gobies, without any definite specific arrangement. These are chiefly *G. minutus*, though *G. microps*, which appears to be quite a distinct form, is also well represented.

G. scorpioides Collett.

One specimen, 11 mm. in length, was taken in a midwater haul (192 A) on 24th October, 1913, 6 miles west of Rame Head, over a depth of 26 fathoms. Previous records of this small goby have been remarkably few, and, as Holt and Byrne have remarked, there is little chance of its being taken unless by special methods. Two adult specimens were taken by Crawshay* in the outer western area of the English Channel, 31 and 33 mm. in length, at a depth of about 50 fathoms.

The pigmentation of the single specimen recorded differs considerably from that of the full-grown adult. Two conspicuous pale bands are represented. One lies across the caudal peduncle, as in the adult; the other occupies a position directly behind the head in the region of the pectoral and first dorsal fins. A faint yellow tinge is present on the caudal and pectoral fins, while alternate dark and light bands are present on the dorsal fins. Pigment is very sparing on the ventrals, being limited to a few dark splashes at the base and on the middle of the larger rays.

Crystallogobius nilssoni Düb. and Kören.

Adult Crystallogobius are frequently met with in the neighbourhood, being especially numerous on the Eddystone Grounds. Sexual dimorphism is a distinct characteristic. The males have considerably more pigment than the females, while the body is deeper and more compressed laterally than in the female, which has a much more slender body and more pointed head. The first dorsal fin is present only in the male, and contains two long rays. The second ray is the longer, and is joined to the body by a wide membrane.

In June, adult males were found in attendance on the eggs, which were attached to the inside of empty tubes of *Chætopterus variopedatus*. These were trawled on the Eddystone Grounds, chiefly in the area south and west of the Eddystone rocks. A similar habitat was noted by Grieg,† who observed the eggs of this species inside tubes of *C. sarsi*.

The records of this species confirm Holt's observations on the pelagic habit of this transparent goby. The young stages have not been sufficiently cleared up to give a definite idea of the distribution and life-history of the species.

TABLE XIX.

RECORD OF CRYSTALLOGOBIUS NILSSONI DÜB. AND KÖR.

No. of Haul.		Date.	Depth.	No.	Size.
VII.	H	30.v.06	S.	6	24·30
XI.	H	20.vi.06	B.	86	21·5–36·5
XXVIII.	H	21.ix.06	B.	1	22
LXI.	H	15.vi.08	B.	6	22–36
CXXIV.	H	6.viii.09	M.	1	29
CXXV.	H	,,	B.	3	29–30
XI.	A	16.vi.13	B.	1	24
XIII.	A	18.vi.13	M.	31	23–28
XIV.	A	,,	B.	14	20–30·5
CXIII.	A	3.ix.13	S.	1	28
CXCII.	A	24.x.13	M.	102	14–26·5
CXCIII.	A	,,	B.	93	14–21·5
CXCIV.	A	,,	M.	17	13–25

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* Journ. M.B.A. N.S., Vol. IX. 1910–13.

† Bergens Museums Aarbog. 1898.

GOBIIDÆ.

Aphya pellucida Nardo.

The post-larval stages of this species are very much like those of Crystallogobius, from which they have been separated with difficulty. The fin formula has been counted in most of the specimens, and has given D 11–12, A 11–12. In a few of the older post-larvæ the rays of the first dorsal were just visible.

Post-larvæ occurred from June to September with a maximum in July and August. Spawning would thus be at its height in June and July. Post-larvæ of *A. pellucida* are seen to be widely distributed over the area investigated, though frequency is highest within the ten-fathom line.

TABLE XX.

Record of Aphya pellucida Nardo.

No. of Haul.	Date.	Depth.	No.	Size.
II. A	6.vi.13	B.	53	7·7–10·5
III. A	11.vi.13	M.	4	6·02–11·4
V. A	12.vi.13	M.	4	6·3–8
IX. A	13.vi.13	B.	1	8·4
XXVI. A	8.vii.13	—	4	8·5–10
XXVII. A	10.vii.13	S.	1	9
XXVIII. A	11.vii.13	M.	8	8–11
XXIX. A	,,	S.	1	11
XXXI. A	14.vii.13	S.	2	8·3–8·68
XXXII. A	15.vii.13	B.	3	8.5–11·5
XXXIV. A	16.vii.13	M.	1	6
XXXV. A	17.vii.13	S.	21	6–14·5
XXXVI. A	18.vii.13	M.	5	6–9·5
XXXVII. A	24.vii.13	B.	7	5·5–12
XXXVIII. A	,,	M.	9	6·5–12
XL. A	28.vii.13	M.	12	10·5–11
XLI. A	,,	M.	61	8–16
XLII. A	,,	M.	11	6·5–12·5
XLIII. A	,,	S.	5	damaged
XLIV. A	29.vii.13	S.	1	8·5
XLVI. A	,,	M.	32	7·5–10·5
XLVII. A	30.vii.13	S.	1	11
XLVIII. A	,,	B.	14	4·5–10·5
XLIX. A	31.vii.13	B.	3	7–7·5
LIII. A	1.viii.13	S.	17	4·5–12
LIV. A	2.viii.13	S.	33	4·5–16
LV. A	,,	S.	42	3–16·5
LVI. A	,,	M.	23	5·5–18
LVII. A	,,	M.	13	12·5–16
LVIII. A	,,	S.	16	8–17
LX. A	7.viii.13	S.	1	8·5
LXI. A	,,	M.	7	4–4·5
LXII. A	,,	B.	13	5–7
LXIII. A	,,	M.	5	3·14–8
LXIV. A	11.viii.13	M.	3	ca. 6
LXV. A	,,	B.	2	3·68–12 5
LXXI. A	13.viii.13	S.	128	4–14
LXXII. A	,,	S.	158	4·5–15
LXXIII. A	,,	S.	49	4·5–12·5

TABLE XX.—*Continued.*

RECORD OF APHYA PELLUCIDA NARDO.

No. of Haul.	Date.	Depth.	No.	Size.
LXXIV. A	13. viii. 13	M.	154	3–14
LXXV. A	,,	S.	8	5–15
LXXVI. A	14.viii.13	S.	14	4·5–12
LXXIX. A	18.viii.13	B.	3	8·5–11
LXXXIX. A	22.viii.13	B.	2	9–14·5
XC. A	,,	B.	27	4·5–14
XCII. A	25.viii.13	M.	2	8–14·5
XCV. A	,,	M.	2	5·5–9
XCVI. A	,,	B.	2	8·5–10
XCVII. A	,,	B.	4	5·5–12
XCIX. A	26.viii.13	M.	2	ca. 8
CI. A	27.viii.13	M.	4	7·5–9·5
CII. A	,,	M.	1	11
CXI. A	3.ix.13	M.	8	8–15
CLVI. A	20.ix.13	M.	3	ca. 8
CLX. A	22.ix.13	B.	1	15·5
CLXV. A	24.ix.13	B.	1	19
CLXX. A	25.ix.13	B.	1	6·03
CLXXIV. A	26.ix.13	B.	1	7
CLXXIX. A	29.ix.13	B.	3	8·10
CLXXXIV. A	1.x.13	B.	1	19·5

COTTIDÆ.

Cottus bubalis Euphr.

Spawning begins in January. Eggs were taken attached to stones between tide-marks on Drake's Island. Post-larvæ occurred from March to June, with their maximum in the last month.

TABLE XXI.

RECORD OF COTTUS BUBALIS.

No. of Haul.	Date.	Depth.	No.	Size.
II. H	22.v.06	S.	2	6–10
III. H	,,	M.	3	4·5–8
VIII. H	30.v.06	B.	1	7·5
XI. H	20.vi.06	B.	3	ca. 8
XIV. H	,,	B.	2	6·5
XVII. H	28.vi.06	B.	1	5
XXXI. H	25.iii.07	S.	6	7·10
XXXII. H	,,	M.	1	7·5
XXXIII. H	11.iv.07	M.	4	4·5–9
XXXIV. H	,,	B.	4	5·5–11·5
XXXV. H	6.vi.07	B.	6	6–8
XLIV. H	28.v.08	?	2	5–7
LVIII. H	10.vi.08	B.	2	5·5–6
LXVI. H	19.vi.08	B.	1	8
LXVII. H	,,	S.	4	ca. 5
LXVIII. H	,,	B.	2	ca. 4
XXIV. H	30.vi.08	?	1	4
XCV. H	28.iv.09	S.	7	3–6
XCVI. H	,,	B.	1	5
XCVII. H	3.v.09	?	1	4
XCIX. H	13.v.09	M.	3	7–8
CIV. H	2.vi.09	B.	1	6
CIX. H	25.vi.09	S.	2	7·5–8

CYCLOPTERIDÆ.

Cyclopterus lumpus L. *Cyclogaster montagui* Donov.

Cyclopterus lumpus L.

Only one specimen of the lumpsucker is recorded. It was taken in the Zostera bed of Cawsand Bay in a midwater haul on 24th September, 1913. The total length was 18 mm.

Cyclogaster montagui Donov.

Post-larvæ of this species occurred most frequently in June, at lengths ranging from 3 to 7·07 mm. The capture of two specimens 5·6 and 6·7 mm. in length in August and September, in bottom hauls, seems to suggest a long post-larval life. In these, the sucker was well developed in front of the abdomen, as in Ehrenbaum's Fig. C, "Nordisches Plankton," Vol. I.

TABLE XXII.

Record of Cyclogaster montagui.

No. of Haul.		Date.	Depth.	Cyclogaster montagui. No.	Size.
VI.	H	30.v.06	B.	4	4·5–6
VII.	H	,,	S.	1	7·5
VIII.	H	,,	B.	1	ca. 8
XI.	H	20.vi.06	B.	1	7
XVII.	H	28.vi.06	B.	2	4·5–6
XX.	H	20.vii.06	B.	1	6
XXI.	H	27.vii.06	B.	1	5·5
XXXV.	H	6.vi.07	B.	6	ca. 5
LIII.	H	4.vi.08	S.	1	6
LXVIII.	H	19.vi.08	B.	1	8
LXX.	H	23.vi.08	M.	1	6·7
LXXI.	H	,,	B.	2	4·3
CV.	H	10.vi.09	B.	?	?
CIX.	H	25.vi.09	B.	1	7
XIV.	A	18.vi.13	B.	1	7·07
XCVI.	A	25.viii.13	B.	1	5·695
CLX.	A	22.ix.13	B.	1	6·7

TRIGLIDÆ.

Trigla gurnardus L. *T. hirundo* Bl. *T. cuculus* L. *T. lineata* (Ray).

Our knowledge of post-larval gurnards is extremely limited. Only *T. gurnardus* and *T. hirundo*, two of the five species that occur at Plymouth, are known with any degree of certainty. *Trigla gurnardus* is well represented in the collection, and appears to be the commonest post-larval form. *T. hirundo* has been partially worked out by Emery* for the Mediterranean, and his descriptions of the post-larval forms have been extremely helpful. Specific characters which have been found most useful have reference to the pectoral fins. These are extremely long in *T. gurnardus*, and have the pigment scattered as black dots between the rays mostly on the posterior half of the fin. In *T. hirundo* the pectorals are much shorter and broader, more deeply pigmented over the whole surface, and appear almost as a uniform brownish black.

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* Mittheil. Zool. Sta. Neapel, vi, 1886.

An entirely different form appears in August and September. This, by a process of elimination, is most probably *T. lineata,* which is known to spawn about July. The early post-larva has very little pigment except for a distinct narrow dark band along the dorsal and posterior margin of the abdominal region, somewhat similar to what occurs in *Cottus bubalis.*

With the material at my disposal, I hope to give a fuller account of the different species in a later contribution.

TRACHINIDÆ.

Trachinus vipera Cuv. *T. draco* L.

T. vipera Cuv. (Lesser Weever.)

Pelagic post-larvæ of the lesser weever were found to be generally distributed and comparatively numerous. They were taken at the mouth of the Lynher River, in the Sound, Cawsand Bay, and over depths ranging from ten to about forty fathoms. The frequency was highest beyond the twenty-fathom line. They occurred from April to September, so that the spawning of this species, as with the dragonet, is indefinitely prolonged. The maximum for the post-larvæ lies in July and August.

T. draco L. (Greater Weever.)

Records of the greater weever are limited to four specimens from 6 to 7 mm. in length, secured in August and September. The appearance of these post-larvæ corresponds to Ehrenbaum's Fig. f, "Nordisches Plankton," Vol. I. Adults of this species are by no means common in the neighbourhood. Those which have been observed have been captured in deeper water.

TABLE XXIII.

RECORD OF TRACHINUS DRACO.

No. of Haul.		Date.	Depth.	No.	Size. mm.
XCIX.	A.	26.viii.13	M.	2	6–7
CXVII.	A.	5.ix.13	M.	1	6
CLXXVI.	A.	26.ix.13	B.	1	6·5

CALLIONYMIDÆ.

Callionymus lyra L.

Hefford recorded the eggs of the dragonet from 11th February to 30th August, but they have been observed this year in January. There is thus an indefinitely prolonged spawning period in the Plymouth district. This is borne out by the post-larval records, which extend from March to September, with a maximum for the middle months of the year—May, June, and July. The distribution of the post-larvæ is general, but there is a distinct concentration in numbers between the twenty and thirty fathom lines, where the adults are also very numerous. The frequency is low inshore within the twenty-fathom line. Between the ten and twenty fathom lines, and also between the thirty and forty, the percentage is fairly high, and shows only a slight decrease from the numbers in the area included between these two regions.

GOBIESOCIDÆ.

Lepadogaster bimaculatus Donov. *L. gouani* Lacep. *L. candollei* Risso.

The distribution of these three species is well marked by the records in Table 24. There are two types represented—the littoral type in *L. gouani* and *L. candollei*, and the deeper water type in *L. bimaculatus*. The frequency of *L. bimaculatus* is high beyond the twenty-fathom line and low in depths less than twenty fathoms. Post-larval *L. bimaculatus* occurred from June to September with a maximum in July. Spawning thus begins in May and extends to August. Ova were frequently found in June and July attached to the inside of empty pecten shells taken in the otter trawl on the Eddystone Grounds. Adult males were generally in attendance.

TABLE XXIV.

RECORD OF LEPADOGASTER SP.

				L. bimaculatus.		L. gouani.		L. candollei.	
No. of Haul.		Date.	Depth.	No.	Size.	No.	Size.	No.	Size.
XIV.	H	20.vi.06	B.	12	7·5–11	—	—	—	—
XVII.	H	28.vi.06	B.	4	4–7	—	—	—	—
XIX.	H	20.vii.06	S.	—	—	1	5·5	19	4·5–7·5
XX.	H	,,	M.	11	5·5–10·5	—	—	2	5–6
XXI.	H	27.vii.06	?	25	5–10·5	—	—	—	—
XXII.	H	,,	?	6	4·7–10	—	—	1	6
XXVIII.	H	21.ix.06	B.	1	17	—	—	—	—
XXXV.	H	6.vi.07	B.	9	6–10	—	—	—	—
XXXIX.	H	10.vii.07	B.	3	5–6	—	—	—	—
XL.	H	19.vii.07	B.	1	7	—	—	—	—
XLIII.	H	28.v.08	M.	—	—	3	5–6	—	—
XCVII.	H	3.v.09	?	—	—	1	4·6	—	—
CIV.	H	2.vi.09	B.	1	9	—	—	—	—

TABLE XXIV.—*Continued.*

RECORD OF LEPADOGASTER SP.

				L. bimaculatus.		L. gouani.		L. candollei.	
No. of Haul.		Date.	Depth.	No.	Size.	No.	Size.	No.	Size.
CXVIII.	H	13.vii.09	M.	3	6–7·5	—	—	—	—
CXXI.	H	20.vii.09	?	9	6–10	—	—	—	—
CXXII.	H	,,	?	11	5–8	—	—	—	—
CXXV.	H	6.viii.09	B.	5	5–7·5	—	—	—	—
III.	A	11.vi.13	M.	1	5·32	—	—	—	—
V.	A	12.vi.13	M.	1	6	—	—	—	—
X.	A	16.vi.13	B.	—	—	1	7·46	—	—
XXI.	A	24.vi.13	S.	1	5·18	—	—	—	—
XXV.	A	7.vii.13	B.	—	—	—	—	1	6·02
XLVI.	A	29.vii.13	M.	1	8·5	—	—	—	—
XLVII.	A	30.vii.13	S.	—	—	—	—	1	7·5
XLVIII.	A	,,	B.	—	—	—	—	5	6–8
XLIX.	A	31.vii.13	B.	1	9·5	—	—	—	—
LIII.	A	1.viii.13	S.	1	mtd.	—	—	—	—
LVI.	A	2.viii.13	M.	1	8	—	—	—	—
LVIII.	A	,,	S.	8	5·5–10	—	—	—	—
LX.	A	7.viii.13	S.	—	—	—	—	1	7·5
LXIII.	A	,,	M.	2	6–6·5	—	—	—	—
LXXII.	A	13.viii.13	S.	2	5·025–6·628		—	—	—
LXXX.	A	18.viii.13	M.	—	—	1	5·5	1	7
XC.	A	22.viii.13	B.	—	—	1	6·5	1	7·5
XCII.	A	25.viii.13	M.	1	10·5	—	—	—	—
XCV.	A	,,	M.	1	7	—	—	—	—
XCVI.	A	,,	B.	1	6	—	—	—	—
XCVII.	A	,,	B.	3	5–7	—	—	—	—
XCVIII.	A	,,	M.	1	7·5	—	—	—	—
CII.	A	27.viii.13	M.	3	7	—	—	—	—
CXV.	A	5.ix.13	M.	2	7·5–9	—	—	—	—
CXXVI.	A	9.ix.13	B.	1	5·5	—	—	—	—

BLENNIIDÆ.

Blennius pholis L. *B. ocellaris* L.

Considerable difficulty has been experienced in determining all the individuals specifically, owing to our incomplete knowledge of the early post-larval stages. Records will be found on Table 25, a general survey of which reveals the presence of two main types, those forms which occur most frequently offshore, and those with a higher frequency inshore. The offshore type is represented by *B. ocellaris*, the inshore chiefly by *B. pholis*.

Eggs of *B. ocellaris* were found continuously from June to August inside empty Buccinum shells which were trawled on the Eddystone Grounds. In nearly every case an adult blenny was taken in attendance. Several of these adults were measured and gave lengths of 120 and 130 mm.

TABLE

EXPLANATION OF

∝ = several thousands.
m = many.
v.m. = very many.

No. of Haul.	Clupea sp.		Ammodytes sp.		Labrus bergylta.		Ctenolabrus rupestris.		Arnoglossus sp.	
	No.	Size.	No.	Size.	No.	Size.	No.	Size.	No.	Size.
I. H	—	—	—	—	—	—	—	—	—	—
II. H	—	—	—	—	—	—	—	—	—	—
III. H	19	12–24	4	10–29	3	7	—	—	—	—
IV. H	3	9–10	—	—	—	—	—	—	—	—
V. H	70	18–30	—	—	—	—	—	—	—	—
VI. H	7	9–16·5	14	6–17·5	7	4·5–7	—	—	—	—
VII. H	∝	26–47	1	12	—	—	—	—	—	—
VIII. H	1	11·5	1	10	—	—	—	—	—	—
IX. H	1	22	1	10·5	2	4	—	—	1	4·5
X. H	4	10–12	2	9–15	3	4·7–6	—	—	1	4·5
XI. H	4	17–20	1	11	1	6	—	—	—	—
XII. H	7	12–17·5	1	10	—	—	—	—	2	5·5–7
XIII. H	23	12–20	3	10–17	—	—	—	—	—	—
XIV. H	1	13	—	—	1	24	5	3·9–4·5	1	5·5
XV. H	5	9–11	1	7·6	60	3·7–5·5	14	3·8–4·5	1	4
XVI. H	66	10·5–19	28	6·5–18	4	4–7·5	—	—	3	5–7·5
XVII. H	1	18	—	—	—	—	—	—	—	—
XVIII. H	22	11–24	3	7–12·5	56	3·25–7	7	5–8	—	—
XIX. H	23	10·5–16·5	4	7–16·5	—	—	3	6·5–8	1	6·5
XX. H	7	15–20	12	8–23	1	7·3	3	8	—	—
XXI. H	1	12·5	1	17	3	4·2–7	1	7·5	—	—
XXII. H	—	—	—	—	—	—	—	—	—	—
XXIII. H	—	—	—	—	—	—	—	—	—	—
XXIV. H	—	—	—	—	—	—	—	—	18	13–26
XXV. H	—	—	—	—	—	—	—	—	1	26·5
XXVI. H	—	—	—	—	—	—	—	—	2	19–21
XXVII. H	2	4·5–18	1	15	—	—	—	—	—	—
XXVIII. H	—	—	—	—	—	—	—	—	—	—
XXIX. H	—	—	—	—	—	—	—	—	—	—
XXX. H	1	7	—	—	—	—	—	—	—	—
XXXI. H	14	10–20	1	8·5	—	—	—	—	—	—
XXXII. H	10	3–5	—	—	—	—	—	—	—	—
XXXIII. H	15	5–14·5	3	6·5–12·5	—	—	—	—	—	—
XXXIV. H	5	7–11	3	7–8	—	—	—	—	—	—
XXXV. H	3	9–12	—	—	2	4	—	—	—	—
XXXVI. H	—	—	—	—	—	—	—	—	—	—
XXXVII. H	—	—	—	—	1	5	—	—	—	—
XXXVIII. H	—	—	—	—	6	—	—	—	—	—
XXXIX. H	1	16	—	—	1	—	—	—	—	—
XL. H	—	—	12	13–22	2	8–20	—	—	—	—
XLI. H	20	9–18	—	—	—	—	—	—	—	—
XLII. H	8	4	—	—	—	—	—	—	—	—
XLIII. H	—	—	—	—	—	—	—	—	—	—
XLIV. H	27	11–21	—	—	3	5–7·5	—	—	—	—
XLV. H	—	—	—	—	—	—	—	—	—	—
XLVI. H	4	10–12	—	—	—	—	—	—	—	—
XLVII. H	6	12–16	1	23	—	—	—	—	—	—
XLVIII. H	1	10	1	11	—	—	—	—	—	—
XLIX. H	2	12·5–13·5	—	—	—	—	—	—	—	—
L. H	7	10–17	7	7–12·5	—	—	—	—	—	—
LI. H	2	8–9	—	—	—	—	—	—	—	—
LII. H	—	—	—	—	—	—	—	—	—	—
LIII. H	30	7·5–16	—	—	—	—	1	7·5	—	—
LIV. H	2	13–16	—	—	—	—	—	—	—	—
LV. H	—	—	—	—	—	—	—	—	—	—

XXV.

ABBREVIATIONS.

z = damaged specimen.
size = length in mm.

Scophthalmus norvegicus.		Gobius sp.		Trigla sp.		Trachinus vipera.		Callionymus lyra.		Blennius sp.	
No.	Size.	No.	Size.	No.	Size.	No.	Size.	No.	Size.	No	Size
—	—	—	—	—	—	—	—	—	—	—	—
—	—	1	7·3	—	—	—	—	7	4–6	—	—
—	—	22	5–9	—	—	—	—	180	3–7	—	—
25	5–8	2	?	—	—	—	—	54	2·5–5	—	—
1	10·5	2	7–15	2	9–10	—	—	9	3·2–7	1	5·5
19	4–9	8	4–8	13	7–11·5	1	3·5	m.	3–7	1	5·5
—	—	—	—	—	—	—	—	2	6·5	—	—
—	—	m.	6–17	—	—	—	—	3	7–9	—	—
—	—	—	—	—	—	1	3·5	8	3·5–7	5	ca. 4·5
—	—	3	4–4·5	—	—	7	3·5–5	1	3·5	20	4·6–6
—	—	150	5–13	1	7·5	—	—	9	3·5–7	—	—
1	7	—	—	—	—	—	—	—	—	—	—
3	5·5–6	26	6–10	—	—	—	—	42	3–8	—	—
—	—	40	4·5–11·5	5	5·5–7·5	6	4–4·7	37	3·5–7·5	—	—
—	—	2	ca. 5·5	—	—	16	3–4	—	—	67	4·7–6·5
28	4·5–9	10	3–6·3	—	—	—	—	4	2·5–4	20	4–6
—	—	200	3·5–10	38	7·5–11	1	3·7	100	3·5–?	15	4·5–9
—	—	4	7–11	1	8·5	19	3·5–6·5	4	3–5	7	4–8
3	5–6	—	—	4	7·5–12	3	3·5–5	55	2·5–8	—	—
1	6	168	3·5–16	3	5–8·5	3	6–7·5	55	3–8	1	6
—	—	160	5–13	4	7–12	2	4–6	30	3·5–8	1	8
—	—	31	4–10	—	—	—	—	4	3·5–5·5	1	4
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	1	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	13	2·5–?	—	—
—	—	—	—	—	—	—	—	23	2·5–6	—	—
—	—	—	—	1	5	1	3·5	23	2·5–7	—	—
—	—	—	—	1	7	—	—	8	3–6	—	—
2	5–8	12	5–8	3	7·5–17	—	—	79	2·5–8	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	14	—
1	6	—	—	—	—	—	—	—	—	19	—
4	6–9	10	7–9	1	17	—	—	5	ca. 5	—	—
—	—	1	12	2	10–17	—	—	3	4–9	—	—
28	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	1	4	—	—
80	—	—	—	—	—	—	—	—	—	—	—
6	5–8·5	70	4·5–10	—	—	—	—	80	3–7	2	4·5–5
—	—	1	6	—	—	—	—	3	3–5	1	5
—	—	6	4–5	2	10–17	—	—	3	ca. 4	1	5
—	—	14	4–7·5	3	8–9	—	—	12	3·67	—	—
—	—	—	—	—	—	—	—	11	3–5	—	—
—	—	1	5	—	—	—	—	4	4–7	—	—
—	—	4	5–8·5	—	—	—	—	8	3–7·2	—	—
—	—	54	3·2–15	—	—	—	—	—	—	—	—
—	—	720	4–11	—	—	—	—	2	3–6	1	5
14	5·5–8·2	32	4–7·8	1	6	—	—	7	2·7–5	1	5
—	—	1	11	—	—	—	—	2	4–5	—	—
—	—	1	4·5	—	—	—	—	4	3–5	—	—

TABLE XXV.—

	Clupea sp.		Ammodytes sp.		Labrus bergylta.		Ctenolabrus rupestris.		Arnoglossus sp.	
No. of Haul.	No.	Size.	No.	Size.	No.	Size.	No.	Size.	No.	Size.
LVI. H	—	—	—	—	—	—	—	—	—	—
LVII. H	4	10–20	—	—	—	—	—	—	—	—
LVIII. H	32	10–19	9	7–15	3	5·5–9	1	9	—	—
LIX. H	8	8–15	14	6–10	—	—	—	—	—	—
LX. H	17	10–18	1	7	7	7–11	—	—	—	—
LXI. H	9	10–14	—	—	3	5–6	—	—	—	—
LXII. H	2	8–15	—	—	—	—	—	—	—	—
LXIII. H	3	9–12	—	—	—	—	—	—	—	—
LXIV. H	11	11–23	4	11–15	12	4–7·5	1	6	—	—
LXV. H	19	11–23	8	7–9	—	—	—	—	—	—
LXVI. H	25	9–24	1	14	—	—	—	—	—	—
LXVII. H	1	6	—	—	5	—	—	—	—	—
LXVIII. H	2	10–12	—	—	3	3–8·5	—	—	—	—
LXIX. H	—	—	2	7–11	—	—	—	—	—	—
LXX. H	53	17–18	29	6–21	5	3·7–7	1	7	—	—
LXXI. H	m.	8–20	—	—	17	7–12	—	—	—	—
LXXII. H	—	—	—	—	1	4	—	—	—	—
LXXIII. H	—	—	—	—	6	6–10	—	—	—	—
LXXIV. H	8	8–15	5	7·5–13	3	5·5–6·8	—	—	—	—
LXXV. H	6	9–11	2	7–9	—	—	—	—	—	—
LXXVI. H	1	10	—	—	17	3·5–5	1	5·5	—	—
LXXVII. H	18	23–27	—	—	4	3–10	—	—	—	—
LXXVIII. H	—	—	—	—	4	6–7·5	—	—	—	—
LXXIX. H	6	13–15	11	6–13	13	3·7–5·5	2	6–9·5	—	—
LXXX. H	40	10–15	8	8–13	71	3·5–11	—	—	—	—
LXXXI. H	2	7–10	68	5–20	3	—	—	—	—	—
LXXXII. H	3	7·5–12	3	5–12·5	17	4·5–6	14	4–7	2	4–6
LXXXIII. H	—	—	—	—	19	4·5–7	4	4	3	4–6
LXXXIV. H	1	17	3	9–17	—	—	1	4·7	—	—
LXXXV. H	—	—	7	7–13	—	—	—	—	—	—
LXXXVI. H	—	—	3	8–17·5	—	—	—	—	2	7·5–8·5
LXXXVII. H	—	—	13	5–16	1	9	—	—	—	—
LXXXVIII. H	—	—	6	7–17	1	4	5	5·5–7·3	—	—
LXXXIX. H	—	—	1	7	2	4·5–7	—	—	1	3·9
XC. H	—	—	1	19	—	—	—	—	—	—
XCI. H	—	—	—	—	—	—	2	7·5–8·5	—	—
XCII. H	—	—	2	—	—	—	—	—	—	—
XCIII. H	—	—	—	—	—	—	—	—	—	—
XCIV. H	3	20	—	—	2	3·5–4	—	—	—	—
XCV. H	2	7–9	—	—	—	—	—	—	—	—
XCVI. H	5	8–15	1	12	—	—	—	—	—	—
XCVII. H	1	24	1	27	—	—	—	—	—	—
XCVIII. H	5	22–26	—	—	—	—	—	—	—	—
XCIX. H	4	12–17	—	—	—	—	—	—	—	—
C. H	1	20	—	—	—	—	—	—	—	—
CI. H	3	22–27	—	—	—	—	—	—	—	—
CII. H	—	—	—	—	—	—	—	—	—	—
CIII. H	18	12–17	—	—	1	10	—	—	—	—
CIV. H	20	12–17	9	16–32	2	6	—	—	—	—
CV. H	—	—	—	—	1	8	—	—	—	—
CVI. H	—	—	—	—	—	—	—	—	—	—
CVII. H	—	—	—	—	—	—	—	—	—	—
CVIII. H	1	41	—	—	—	—	—	—	—	—
CIX. H	4	18–21	1	10	1	9	—	—	—	—
CX. H	3	12·5–17	—	—	1	5·5	—	—	—	—
CXI. H	52	17–21	4	16	1	10	—	—	—	—
CXII. H	12	10–20	2	15–17	1	6	—	—	—	—
CXIII. H	6	15–19·5	—	—	—	—	—	—	—	—
CXIV. H	—	—	—	—	—	—	—	—	—	—
CXV. H	—	—	—	—	—	—	—	—	—	—

Continued.

Scophthalmus norvegicus.		Gobius sp.		Trigla sp.		Trachinus vipera.		Callionymus lyra.		Blennius sp.	
No.	Size.	No.	Size.	No.	Size.	No.	Size.	No.	Size.	No.	Size.
7	5–9	16	4–8·5	—	—	—	—	6	2·7–?	1	5
—	—	1	7	—	—	—	—	3	2·8–6	—	—
3	4–9	m.	4–9	—	—	—	—	m.	3–8	—	—
—	—	2	ca. 7	1	6	—	—	15	3·2–6·5	2	6–7·5
—	—	51	3·5–15	3	6–7·3	—	—	m.	3–8	—	—
2	5–6	44	4–12	1	7·5	—	—	m.	3·5–10	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	6	5–13	1	5	—	—	—	—	—	—
—	—	1	11	—	—	1	5	2	3·5–5	17	3–6·7
10	5–9	v.m.	4–8	4	4–10	—	—	m.	3–9	—	—
7	7–11	v.m.	4–15	3	7–10	—	—	v.m.	3–9	—	—
—	—	20	4–8	—	—	1	2·5	—	—	2	5–6
—	—	m.	4–7·3	2	7–9·5	—	—	3	4·5–8	6	5–7·5
—	—	—	—	—	—	—	—	4	2–4	—	—
58	3·5–11	84	3–9	29	5–17	3	3·7–7	50	3–8	1	5·4
—	—	m.	5–12	6	ca. 16	1	4	v.m.	2·7–10	—	—
—	—	2	ca. 13	1	7·5	—	—	—	—	—	—
—	—	60	8–26	—	—	—	—	—	—	2	4–6
17	3·7–6	8	4–7	—	—	—	—	—	—	—	—
10	5–7	m.	4–8	—	—	1	3	v.m.	2·5–?	—	—
1	4	24	3·5–5	1	5·2	1	4·5	5	2·8–7·5	7	4·5–6
—	—	v.m.	4–14	1	10	—	—	—	—	—	—
—	—	6	3·7–13	—	—	—	—	—	—	1	4·5
—	—	9	3–6	—	—	2	3·3–5·2	2	4–6	12	4–6
—	—	120	3–11	1	11	—	—	21	2·5–8	1	4·5
—	—	3	3–4·5	—	—	—	—	20	2·2–4	2	4·5–5
—	—	15	2·8–6	—	—	2	4–5	1	3	14	4–5·5
—	—	—	—	—	—	4	3–4	—	—	—	—
—	—	4	5·5–7	—	—	—	—	—	—	2	7–8
—	—	—	—	—	—	—	—	2	3·8–5	—	—
—	—	10	3·7–5	—	—	1	5	2	3·3–7	1	7
—	—	5	4–6	—	—	1	5	1	5	—	—
—	—	2	6–8	—	—	—	—	—	—	—	—
—	—	3	5–7	—	—	—	—	—	—	—	—
—	—	7	6·5–11·5	—	—	—	—	—	—	—	—
—	—	10	10–11	—	—	—	—	—	—	—	—
—	—	1	9	—	—	—	—	—	—	—	—
—	—	9	4·5–7	—	—	—	—	—	—	—	—
—	—	11	3·7–8	—	—	—	—	—	—	—	—
—	—	2	2·6–6	—	—	—	—	1	12	—	—
—	—	52	3·5–10	—	—	—	—	—	—	—	—
—	—	62	2·7–9	—	—	—	—	7	3·7	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	4	6–8·5	—	—	—	—	12	4·7	—	—
—	—	1	4·5	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	3	4·5	—	—
—	—	1	7·5	—	—	—	—	5	5–8·5	—	—
—	—	2	7–8	2	7·5–9	—	—	19	3·7–7·5	—	—
3	6–8	5	7–8	15	7–10	—	—	v.m.	4·5–8	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	7	8–13	—	—	—	—	—	—	—	—
—	—	1	7·5	—	—	—	—	—	—	—	—
—	—	2	9–13	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
2	6·5	4	7–8	4	7·5–12	—	—	v.m	3·5–8	—	—
—	—	—	—	—	—	1	6·5	—	—	24	4·5–9
—	—	2	4–8	—	—	5	4–5	3	5·5–6	2	7–7·5
10	7–9	3	4–8	1	7·5	—	—	14	3·5–7·5	1	8
—	—	—	—	—	—	—	—	—	—	—	—
—	—	17	7–16	—	—	—	—	—	—	—	—

TABLE XXV.—

No. of Haul.	Clupea sp.		Ammodytes sp.		Labrus bergylta.		Ctenolabrus rupestris.		Arnoglossus sp.	
	No.	Size.	No.	Size.	No.	Size.	No.	Size.	No.	Size.
CXVI. H	—	—	—	—	1	11	—	—	—	—
CXVII. H	—	—	—	—	1	7	—	—	—	—
CXVIII. H	1	7·5	26	7–17	—	—	—	—	2	13
CXIX. H	—	—	1	9	6	4–7	—	—	—	—
CXX. H	60	9–22·5	1	8	—	—	—	—	3	5·5–17·5
CXXI. H	30	8–23	8	7–26	1	4·5	—	—	4	5–19·5
CXXII. H	36	12–16	21	7·2–29	1	5	—	—	—	—
CXXIII. H	—	—	—	—	1	4	—	—	1	3
CXXIV. H	1	10	4	9–14	1	4	—	—	3	4–6·5
CXXV. H	3	17–20	8	11–22	1	3	—	—	4	5–6
CXXVI. H	—	—	—	—	1	7	—	—	—	—
CXXVII. H	2	16–22·5	—	—	—	—	—	—	—	—
CXXVIII. H	—	—	—	—	—	—	—	—	—	—
CXXIX. H	1	17	2	5–7	—	—	—	—	—	—
CXXX. H	4	17	3	12–13	—	—	1	7	—	—
CXXXI. H	—	—	—	—	—	—	—	—	—	—
CXXXII. H	—	—	1	11	—	—	—	—	—	—
I. A	13	8–18	—	—	—	—	—	—	—	—
II. A	m.	8·5–21·5	1	15·5	—	—	—	—	—	—
III. A	263	12–20	2	14·5	—	—	—	—	—	—
IV. A	—	—	8	14·5–20·3	—	—	—	—	—	—
V. A	48	7·25–20	7	14–23	—	—	—	—	1	5·39
VI. A	10	12–22	—	—	—	—	—	—	—	—
VII. A	17	13·5–17	—	—	—	—	—	—	—	—
VIII. A	36	12·5–20	1	15	1	7·6	—	—	—	—
IX. A	21	14–32·5	30	67–104	2	8·6–9	—	—	—	—
X. A	13	z	—	—	1	8·9	—	—	—	—
XI. A	4	13–15	—	—	—	—	—	—	—	—
XII. A	17	11–18	—	—	—	—	—	—	—	—
XIII. A	27	16–19	—	—	—	—	—	—	—	—
XIV. A	295	14–22	—	—	—	—	—	—	—	—
XV. A	—	—	—	—	—	—	—	—	—	—
XVI. A	9	15–19·5	1	14	—	—	1	7·14	—	—
XVII. A	5	10–19	—	—	—	—	—	—	—	—
XVIII. A	42	18–25	1	31	1	8·75	—	—	—	—
XIX. A	3	13·5–19	—	—	—	—	2	5·6–6·5	—	—
XX. A	2	16	—	—	—	—	1	6·95	—	—
XXI. A	2	11·5–16	—	—	1	5·95	—	—	—	—
XXII. A	19	9·5–20	—	—	2	5·5–6·5	—	—	—	—
XXIII. A	10	11–18·5	1	15·5	—	—	1	9·8	4	6·4–7·12
XXIV. A	13	10·5–20	3	15–28	2	7·7–9·9	1	7	—	—
XXV. A	—	—	—	—	3	8·26–9·7	19	8–9·2	—	—
XXVI. A	1	12·5	2	6–8	3	z	4	5·25–7	—	—
XXVII. A	—	—	—	—	—	—	—	—	—	—
XXVIII. A	7	11·5–18	2	11·5–14·5	1	z	—	—	—	—
XXIX. A	1	15	4	9·2–4	—	—	—	—	—	—
XXX. A	1	26	—	—	—	—	—	—	—	—
XXXI. A	—	—	—	—	4	3·5–7·5	—	—	—	—
XXXII. A	6	17·5–24	2	11–18·5	1	5·5	1	9·38	—	—
XXXIII. A	2	22·5	—	—	1	5·18	5	7·35–7·7	—	—
XXXIV. A	1	22	4	13–21	—	—	—	—	2	7·9–23
XXXV. A	4	17–22	1	8.68	33	5.5–8	2	8·4	—	—
XXXVI. A	1	z	1	13·5	8	5·5–7	1	8	—	—
XXXVII. A	3	16–23	27	14·5–17·5	—	—	16	5–7	3	5–12·5
XXXVIII. A	1	21	9	6–10	—	—	1	z	1	6
XXXIX. A	2	10–21	26	7–14	36	4·5–7	29	5·5–9·5	1	11·5
XL. A	—	—	—	—	—	—	—	—	—	—
XLI. A	7	22·5–25	—	—	7	5·25–7·2	2	7·28–9·11	—	—
XLII. A	2	z	5	9–15·5	7	3·9–6·3	5	7·28–9·5	—	—
XLIII. A	1	21	—	—	—	—	—	—	—	—

Continued.

Scophthalmus norvegicus.		Gobius sp.		Trigla sp.		Trachinus vipera.		Callionymus lyra.		Blennius sp.	
No.	Size.	No.	Size.	No.	Size.	No.	Size.	No.	Size.	No.	Size.
—	—	—	—	—	—	1	5	—	—	—	—
—	—	7	4–6	—	—	3	3·5–5	3	3·7–5	16	5·2–7
—	—	—	—	—	—	1	4	1	7·5	3	ca. 6
—	—	2	ca. 9	—	—	2	4–6	—	—	24	4–7
—	—	50	3·7–21	—	—	30	3–7	5	4–5·5	6	4·8–6·5
2	7–10	—	—	1	7·5	6	4·5	50	3–10	2	5–8
6	8–10	m.	4–25	6	7–11	4	4–7	40	4–10	1	6
—	—	—	—	—	—	—	—	2	3–5	—	—
—	—	2	5–10	1	4	4	4–5	14	3–7	2	5·5–8
2	5–6·7	23	3·7–13	1	7·5	1	6	14	3–5	1	6
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	1	4	—	—	—	—
—	—	—	—	—	—	1	2·7	—	—	—	—
—	—	—	5–6	—	—	—	—	—	—	—	—
9	6·3–9·64	—	—	—	—	—	—	—	—	—	—
—	—	—	—	1	7·98	—	—	2	ca. 6	—	—
82	?	—	—	4	5·95–8	—	—	80	4–7·05	—	—
—	—	—	—	—	—	—	—	1	3·5	—	—
55	5·25–12·25	—	—	9	6·2–11·9	—	—	15	3·8–6·9	—	—
1	7·7	—	—	14	5·6–11·27	—	—	16	3·2–6·5	—	—
—	—	—	—	1	8	—	—	—	—	—	—
—	—	—	—	1	8·8–15	—	—	19	5·8–8·5	—	—
—	—	—	—	—	—	—	—	—	—	—	—
8	4·5–7·7	—	—	1	9·8	—	—	1	6·37 ca.	—	—
9	5·5–8	1	10·8	—	—	—	—	3	6·6–6·9	—	—
1	9·8	—	—	—	—	—	—	—	—	—	—
9	7·35–10·35	2	11·06-11·69	—	—	—	—	—	—	—	—
11	6·4–10	10	8–15	—	—	—	—	13	5·6–14	—	—
14	6·3–9·8	—	—	1	z	—	—	—	—	—	—
12	5–9	—	—	12	6–13·5	—	—	13	4·6–7·3	—	—
—	—	—	—	6	6·86–10·5	—	—	23	4·7–7·3	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	3	5·7–7·35	—	—
12	4·9–6·5	—	—	—	—	—	—	11	3·8–7	—	—
—	—	1	6	5	10–17	—	—	—	—	—	—
8	4·5–8·5	—	—	1	8·4	—	—	8	5·2–6·3	—	—
30	5–9·5	—	—	1	14	1	4·9	50	3·8–9·8	—	—
2	6·65–6·9	—	—	1	10	—	—	16	4·2–9·1	—	—
1	9·6	2	4·6–4·75	—	—	—	—	—	—	1	9·6
—	—	—	—	—	—	—	—	2	7–7·7	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	24	4·2–6·4	—	—
—	—	—	—	—	—	—	—	1	5·8	—	—
—	—	—	—	—	—	—	—	2	5–6·8	—	—
—	—	—	—	—	—	—	—	—	—	—	—
5	6·5–11	—	—	—	—	—	—	31	5–8·6	—	—
2	6·58–8	—	—	—	—	1	8·05	13	5·6–7·7	1	17·5
—	—	—	—	—	—	—	—	7	4·8–7·6	—	—
—	—	—	—	—	—	2	4·9	—	—	—	—
—	—	—	—	1	9	—	—	11	5–7	—	—
1	8·5	19	7–15·5	2	8·5–15	1	4	1	4·9	1	6·16
—	—	—	—	3	7–17	2	6·3	7	5·5–6·5	2	ca. 7·6
—	—	4	z	—	—	40	5–7·5	1	z	1	6·5
—	—	—	—	1	7·2	1	6·5	1	5·39	—	—
—	—	—	—	—	—	2	5·6–6·6	—	—	2	9–14
—	—	—	—	—	—	3	ca. 7·5	—	—	2	ca. 7
—	—	—	—	—	—	7	ca. 9	—	—	—	—

TABLE XXV.—

		Clupea sp.		Ammodytes sp.		Labrus bergylta.		Ctenolabrus rupestris.		Arnoglossus sp.	
No.	Haul.	No.	Size.	No.	Size.	No.	Size.	No.	Size.	No.	Size.
XLIV.	A	1	20	27	ca. 20	—	—	—	—	5	4·5–14·5
XLV.	A	—	—	6	11–15	—	—	—	—	1	15
XLVI.	A	1	23	2	7–26·5	—	—	7	4·5–6·5	22	4·5–14·5
XLVII.	A	1	25	—	—	—	—	—	—	—	—
XLVIII.	A	—	—	1	7	20	3·4–7·5	2	7·5–8	—	—
XLIX.	A	1	14	20	6·5–16·5	—	—	—	—	21	3·5–20·5
L.	A	—	—	—	—	—	—	—	—	28	7–21·5
LI.	A	—	—	—	—	—	—	—	—	5	6·5–12·5
LII.	A	2	25	1	7	1	5·5	1	6	—	—
LIII.	A	2	14–20	2	10–21	—	—	—	—	7	4·5–23·5
LIV.	A	15	12–22	8	6·5–13	3	6·5–8	—	—	25	4–15
LV.	A	20	12–17	3	7–16	—	—	—	—	33	4–14
LVI.	A	4	11–16	—	—	—	—	—	—	20	5·5–12
LVII.	A	4	13·5–16·5	2	10·5–16	—	—	—	—	9	5–8·5
LVIII.	A	17	9·5–21	—	—	1	5·49	—	—	6	5–13·5
LIX.	A	1	36	—	—	—	—	—	—	—	—
LX.	A	—	—	2	9–14	—	—	2	5·5–6	14	7–21·5
LXI.	A	—	—	7	7·5–23·5	1	5·25	1	6	31	4·5–14·5
LXII.	A	—	—	12	4·5–12	1	5·2	—	—	14	5·5–17
LXIII.	A	1	11	6	6–16·5	—	—	—	—	13	5–12
LXIV.	A	—	—	14	10–19	—	—	—	—	2	5–7·5
LXV.	A	—	—	13	7–15	1	6·16	—	—	3	z
LXVI.	A	—	—	1	14·5	—	—	—	—	1	8·5
LXVII.	A	—	—	—	—	—	—	—	—	4	9–19·5
LXVIII.	A	—	—	1	7	—	—	—	—	7	6·5–10
LXIX.	A	—	—	2	13–17·5	—	—	—	—	4	5–15
LXX.	A	—	—	—	—	2	8	—	—	2	6–6·5
LXXI.	A	—	—	—	—	—	—	—	—	—	—
LXXII.	A	1	24·5	—	—	—	—	—	—	—	—
LXXIII.	A	—	—	—	—	—	—	—	—	2	12–16
LXXIV.	A	—	—	—	—	—	—	—	—	1	11
LXXV.	A	—	—	2	8·5–10·5	—	—	1	7·5	4	7·5–11
LXXVI.	A	1	23	—	—	1	4	—	—	8	6–21
LXXVII.	A	—	—	3	11–17	—	—	—	—	5	8–18
LXXVIII.	A	—	—	5	6·5–21	—	—	—	—	6	7·5–18
LXXIX.	A	1	z	1	6	—	—	—	—	4	10·5–15
LXXX.	A	—	—	2	14	4	6·5–8	—	—	—	—
LXXXI.	A	—	—	—	—	—	—	—	—	—	—
LXXXII.	A	1	23	—	—	—	—	—	—	1	6
LXXXIII.	A	—	—	1	9	—	—	—	—	1	20
LXXXIV.	A	1	24·5	—	—	—	—	—	—	—	—
LXXXV.	A	—	—	—	—	—	—	—	—	—	—
LXXXVI.	A	—	—	1	6·5	—	—	—	—	—	—
LXXXVII.	A	—	—	—	—	—	—	—	—	—	—
LXXXVIII.	A	—	—	—	—	—	—	—	—	—	—
LXXXIX.	A	1	25	—	—	—	—	—	—	—	—
XC.	A	—	—	—	—	1	7	—	—	—	—
XCI.	A	—	—	—	—	—	—	—	—	—	—
XCII.	A	2	21–23	12	10·5–10·5	—	—	—	—	7	7·5–20
XCIII.	A	—	—	2	7·5–10	—	—	—	—	2	13·5–20·5
XCIV.	A	1	14	18	8·5–14	—	—	—	—	2	11–13·5
XCV.	A	—	—	55	6·5–17	—	—	—	—	13	4–16·5
XCVI.	A	—	—	40	8–25	—	—	—	—	10	8–20
XCVII.	A	—	—	42	7·5–15·5	—	—	—	—	7	6–18
XCVIII.	A	—	—	3	9	—	—	—	—	8	ca. 5
XCIX.	A	—	—	56	11·5–22	—	—	1	7	22	8–28·5
C.	A	5	20–20·5	20	6–16·5	—	—	—	—	60	—
CI.	A	—	—	17	8·5–16·5	—	—	—	—	12	4·5–20
CII.	A	4	15·5–17	32	7–18	—	—	—	—	69	4–22
CIII.	A	1	19·5	31	8·5–14·5	—	—	—	—	13	4–19·5

Continued.

Scophthalmus norvegicus.		Gobius sp.		Trigla sp.		Trachinus vipera.		Callionymus lyra.		Blennius sp.	
No.	Size.	No.	Size.	No.	Size.	No.	Size.	No.	Size.	No.	Size.
—	—	—	—	—	—	17	4·5–9	9	5·5–8	—	—
—	—	—	—	—	—	—	—	1	7	—	—
—	—	—	—	3	7–12	112	3·5–8	28	4–8·5	4	5·6–7·5
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	1	4·8	—	—	1	8·5
—	—	—	—	3	7·5–13·5	17	3·5–5·5	17	4·5–8	3	5·5–8
—	—	—	—	—	—	—	—	1	z	—	—
—	—	—	—	1	9	—	—	—	—	—	—
—	—	—	—	—	—	1	4	—	—	1	z
—	—	8	4·5–16·5	—	—	3	4·5–6·5	5	3–8	1	6
—	—	7	4·5–13	—	—	13	4–7·5	29	3–11	1	4·5
—	—	3	ca. 11·5	1	7	10	4–7·5	8	4–7	—	—
—	—	1	3·5	1	8·5	4	3–5·5	4	3·5–5	2	ca. 6
—	—	5	6–13	—	—	2	4–5·5	4	4–10	—	—
—	—	1	10	2	9–16·5	5	4–6·5	4	5–13	1	10
—	—	1	31	—	—	1	18	—	—	1	7
—	—	3	6–7	—	—	27	3·5–9	—	—	2	5·5–7·5
—	—	—	—	—	—	25	3–11·25	—	—	—	—
—	—	—	—	—	—	4	3·75–5	7	3·7–4·6	1	6·03
—	—	—	—	1	4·69	3	4·4–5·1	13	3·0–6·7	—	—
—	—	—	—	—	—	1	7	10	2·75–7·3	—	—
—	—	—	—	—	—	2	3·6	6	3·68–7·2	—	—
—	—	—	—	—	—	1	5·4	2	5·3–6·7	—	—
—	—	—	—	—	—	2	4·5–5·6	3	3·6–6·7	1	4·8
—	—	—	—	1	5·36	6	4·5–8·5	1	5·5	1	5·3
—	—	1	7	—	—	2	4·35	1	4·5	1	6·03
—	—	—	—	—	—	2	5·5–8·5	5	3·8–5·7	1	13
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	3	z	10	5·6–8·7	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	3	5·3–5·6	1	11
—	—	—	—	—	—	—	—	2	4·6–5·5	4	6·5–8
—	—	—	—	3	4·5–11	7	5–6	3	4–6	1	4
—	—	1	z	1	9·5	1	4·35	1	6·03	—	—
—	—	—	—	—	—	1	13·5	—	—	—	—
—	—	3	8·5–11	6	7–10	—	—	3	5·2–8·8	—	—
—	—	—	—	—	—	4	6–7	—	—	—	—
—	—	2	3·5–4	1	z	2	4–9·5	—	—	4	4·5–6·5
—	—	—	—	1	8	1	5·5	—	—	1	10
—	—	—	—	2	6–6·5	1	4	—	—	2	5–7
—	—	—	—	—	—	1	6·5	—	—	—	—
—	—	1	5·06	—	—	—	—	1	6	1	5·5
—	—	1	4·02	—	—	1	4·4	—	—	3	ca. 8
—	—	1	2·8	—	—	4	5–10	—	—	—	—
—	—	2	11–18	—	—	—	—	—	—	1	12·5
—	—	—	—	1	8·5	—	—	—	—	—	—
—	—	2	3–6	—	—	1	8	1	6·5	1	18·5
—	—	—	—	—	—	1	6·5	—	—	1	7
—	—	2	9–12	4	6·5–15	7	3–9	1	8	2	9–13
—	—	1	6·5	4	5·5–20	—	—	1	7·5	3	5–6
—	—	—	—	1	10·5	1	5·5	4	4·5–8·5	—	—
—	—	—	—	2	5–16·5	4	ca. 4·5	10	3–6	3	4·5–5·5
—	—	2	6–8	4	7·5–13·5	1	z	11	4·5–9	—	—
—	—	1	6	2	ca. 8	1	8·75	29	3·5–8·5	—	—
—	—	—	—	2	13·5–15·5	4	4·5–5	4	4·5–7	—	—
—	—	—	—	3	8–9	17	4–9·5	7	4–8	—	—
—	—	4	2·3–56	9	4·2–22	20	4–5	11	3–8	2	5·2–6·7
—	—	2	3–4	4	ca. 6	10	3·5–6	8	3·7–5·6	1	5·2
—	—	3	ca. 4·5	10	6–18	23	3·5–6·9	18	4–5·4	7	4–10·5
—	—	—	—	—	—	3	2·68–5·2	1	5·3	—	—

TABLE XXV.—

	Clupea sp.		Ammodytes sp.		Labrus bergylta.		Ctenolabrus rupestris.		Arnoglossus sp.	
No. of Haul.	No.	Size.	No.	Size.	No.	Size.	No.	Size.	No.	Size.
CIV. A	4	16·5–18·5	20	5–16·5	—	—	—	—	7	4·5–18
CV. A	2	19·5–20	20	6–17	—	—	—	—	21	4–18·5
CVI. A	1	20·5	6	11·5–18	—	—	—	—	14	5–21·5
CVII. A	—	—	—	—	—	—	—	—	—	—
CVIII. A	—	—	—	—	—	—	—	—	2	5–11
CIX. A	—	—	—	—	—	—	—	—	1	z
CX. A	—	—	—	—	—	—	—	—	—	—
CXI. A	1	9·5	—	—	—	—	—	—	4	5–7·5
CXII. A	—	—	—	—	—	—	—	—	—	—
CXIII. A	—	—	—	—	—	—	—	—	3	4·5–5
CXIV. A	—	—	—	—	—	—	—	—	1	6
CXV. A	—	—	1	7	—	—	—	—	4	4·5–10
CXVI. A	—	—	—	—	—	—	—	—	33	4–9·5
CXVII. A	—	—	—	—	—	—	—	—	21	4–21
CXVIII. A	—	—	—	—	—	—	—	—	13	4–19
CXIX. A	—	—	—	—	—	—	—	—	8	6·5–19
CXX. A	—	—	—	—	—	—	—	—	3	4·4–11·5
CXXI. A	—	—	—	—	—	—	—	—	4	6–14·
CXXII. A	—	—	1	5·5	—	—	—	—	11	5–7·5
CXXIII. A	—	—	—	—	—	—	—	—	8	4·5–9
CXXIV. A	—	—	—	—	—	—	—	—	25	4·8–9·5
CXXV. A	7	4·5–5·5	—	—	—	—	—	—	1	4
CXXVI. A	—	—	—	—	—	—	—	—	1	6
CXXVII. A	—	—	—	—	—	—	—	—	—	—
CXXVIII. A	2	3·4	—	—	—	—	—	—	—	—
CXXIX. A	—	—	—	—	—	—	—	—	—	—
CXXX. A	—	—	—	—	—	—	—	—	—	—
CXXXI. A	—	—	—	—	—	—	—	—	6	4·5–8
CXXXII. A	—	—	—	—	—	—	—	—	8	5·5–16
CXXXIII. A	—	—	—	—	—	—	—	—	5	4·5–7
CXXXIV. A	—	—	—	—	—	—	—	—	20	4·5–11
CXXXV. A	—	—	—	—	—	—	—	—	1	7·5
CXXXVI. A	—	—	—	—	—	—	—	—	4	4·5–5
CXXXVII. A	—	—	—	—	—	—	—	—	?	4·8–6·5
CXXXVIII. A	—	—	—	—	—	—	—	—	5	6–8·5
CXXXIX. A	—	—	—	—	—	—	—	—	10	6·5–8
CXL. A	—	—	—	—	—	—	—	—	7	5–9·75
CXLI. A	—	—	—	—	—	—	—	—	11	5·5–12
CXLII. A	—	—	—	—	—	—	—	—	23	4·5–10
CXLIII. A	—	—	1	6·5	—	—	—	—	4	4·25–6·25
CXLIV. A	—	—	—	—	—	—	—	—	8	6–8
CXLV. A	—	—	—	—	—	—	—	—	3	5·36–5·67
CXLVI. A	2	5–5·6	—	—	—	—	—	—	—	—
CXLVII. A	1	5	—	—	—	—	—	—	—	—
CXLVIII. A	1	4·5	—	—	—	—	—	—	—	—
CXLIX. A	2	4·75–5	—	—	—	—	—	—	—	—
CL. A	4	5	—	—	—	—	—	—	—	—
CLI. A	—	—	—	—	—	—	—	—	1	6·25
CLII. A	1	6·25	1	11·25	—	—	—	—	5	7–10
CLIII. A	—	—	—	—	—	—	—	—	1	z
CLIV. A	—	—	—	—	—	—	—	—	4	10·25–18
CLV. A	2	5·25–13	1	20	—	—	—	—	10	9·5–17
CLVI. A	2	3·5–5	2	9·5–10·5	—	—	—	—	49	4·5–18·5
CLVII. A	1	5·25	—	—	—	—	—	—	—	—
CLVIII. A	16	4–12	—	—	—	—	—	—	3	3·5–31
CLIX. A	2	3·5–8·5	—	—	—	—	—	—	9	8·5–16·5
CLX. A	—	—	—	—	—	—	—	—	9	6·5–15
CLXI. A	3	4·5–6	—	—	—	—	—	—	6	ca. 3–16
CLXII. A	1	z	—	—	—	—	—	—	7	z
CLXIII. A	3	6–8·5	—	—	—	—	—	—	3	z

Continued.

Scophthalmus norvegicus.		Gobius sp.		Trigla sp.		Trachinus vipera.		Callionymus lyra.		Blennius sp.	
No.	Size.	No.	Size.	No.	Size.	No.	Size.	No.	Size.	No.	Size.
—	—	—	—	2	5–10	8	4–9	2	4·3–7	1	6·2
—	—	—	—	1	15	36	3–7	9	3–7	—	—
—	—	2	3·68–3·75	1	6·5	6	z	4	3·5–10	—	—
—	—	—	—	—	—	—	—	—	—	2	z
—	—	—	—	3	8–11	1	4	—	—	3	5·5–14·5
—	—	—	—	2	8·5–14	—	—	—	—	—	—
—	—	—	—	1	5·5	—	—	—	—	—	—
—	—	—	—	—	—	1	4	—	—	—	—
—	—	18	9–24·5	—	—	—	—	—	—	—	—
—	—	58	10–22	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	1	6	—	—
—	—	2	3·5–5·5	—	—	—	—	2	5·5–7·5	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	1	3·5	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	1	6·5
—	—	—	—	—	—	1	4	—	—	—	—
—	—	—	—	—	—	—	—	—	—	1	7
—	—	3	5–6·5	—	—	—	—	3	4–7	—	—
—	—	3	ca. 4·5	1	6·5	—	—	2	5–6	—	—
—	—	—	—	1	5	—	—	8	5–9	—	—
—	—	2	4·5–7·5	3	3·5–4·5	1	7	1	5·5	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	2	3·5–6	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	1	15	—	—	—	—	—	—
—	—	—	—	—	—	2	4·5	—	—	1	8·5
—	—	—	—	2	ca. 5·5	—	—	—	—	—	—
—	—	—	—	1	6·5	—	—	2	5·5–6	1	7·5
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	1	6	—	—	1	7	—	—
—	—	—	—	—	—	—	—	—	—	1	7·25
—	—	—	—	2	5·5–7·5	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	2	5–7·5	—	—	—	—	—	—
—	—	—	—	4	6–10·5	1	18	—	—	4	5–11·5
—	—	—	—	1	9·5	2	3·5–5·5	3	5·5	1	7·5
—	—	—	—	4	5·75–6·5	—	—	—	—	—	—
—	—	—	—	3	6–1	—	—	—	—	1	6
—	—	—	—	—	—	1	z	—	—	1	13·25
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	1	6	—	—	1	7	—	—
—	—	—	—	2	6·5–7	—	—	—	—	—	—
—	—	—	—	1	13	—	—	1	5	1	z
—	—	—	—	5	5·25–7	1	4·25	—	—	1	6·25
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	1	z	—	—	—	—	—	—
—	—	1	4·25	2	5·5–11·5	1	z	—	—	1	8·5
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	1	z	—	—	—	—	—	—
—	—	—	—	9	6·5–15	—	—	2	z	—	—
—	—	—	—	1	9·5	1	9	—	—	—	—

TABLE XXV.—

	Clupea sp.		Ammodytes sp.		Labrus bergylta.		Ctenolabrus rupestris.		Arnoglossus sp.	
No. of Haul.	No.	Size.	No.	Size.	No.	Size.	No.	Size.	No.	Size.
CLXIV. A	7	14–24	—	—	—	—	—	—	—	—
CLXV. A	—	—	—	—	—	—	—	—	—	—
CLXVI. A	20	5–8	—	—	—	—	—	—	—	—
CLXVII. A	2	5·25	—	—	—	—	—	—	2	z
CLXVIII. A	38	7·5–8	—	—	—	—	—	—	—	—
CLXIX. A	24	5–9	—	—	—	—	—	—	12	5–11
CLXX. A	5	6·5–8	—	—	—	—	—	—	?	—
CLXXI. A	38	6–15·5	1	17·5	—	—	—	—	145	5–20
CLXXII. A	—	—	2	19–24	—	—	—	—	2	z
CLXXIII. A	—	—	1	12	—	—	—	—	17	5–11·5
CLXXIV. A	9	7–16	1	12	—	—	—	—	24	4·5–19
CLXXV. A	2	10–19	—	—	—	—	—	—	2	17–19
CLXXVI. A	12	5–9·5	—	—	—	—	—	—	57	4–13·5
CLXXVII. A	4	5–8·5	—	—	—	—	—	—	10	4·5–11·5
CLXXVIII. A-	7	6–11	—	—	—	—	—	—	4	6–17
CLXXIX. A	5	7·5–8	—	—	—	—	—	—	24	5–18
CLXXX. A	22	5·5–10	—	—	1	4·5	—	—	2	4·5
CLXXXI. A	3	7–13	—	—	—	—	—	—	1	6
CLXXXII. A	3	6–10	1	22	—	—	—	—	7	9·5–18
CLXXXIII. A	12	10·5–12	—	—	—	—	—	—	13	5–18·5
CLXXXIV. A	12	8–13	—	—	—	—	—	—	—	—
CLXXXV. A	8	4.5–10.5	—	—	—	—	—	—	—	—
CLXXXVI. A	14	3·5–11	—	—	—	—	—	—	1	7
CLXXXVII. A	4	7–10	—	—	—	—	—	—	—	—
CLXXXVIII. A	17	5–12	—	—	—	—	—	—	—	—
CLXXXIX. A	26	6–18	—	—	—	—	—	—	—	—
CXC. A	17	7·5–17	—	—	—	—	—	—	1	z
CXCI. A	9	8·5–12·5	—	—	—	—	—	—	—	—
CXCII. A	228	5·5–24	—	—	—	—	—	—	—	—
CXCIII. A	44	8–15·25	—	—	—	—	—	—	—	—
CXCIV. A	102	7·25–18·5	—	—	—	—	—	—	—	—
CXCV. A	3	5–10·5	—	—	—	—	—	—	—	—
CXCVI. A	2	7–19·5	—	—	—	—	—	—	—	—
CXCVII. A	37	7–16	—	—	—	—	—	—	—	—
CXCVIII. A	17	7·5–21	—	—	—	—	—	—	—	—
CXCIX. A	22	5·5–19	—	—	—	—	—	—	—	—
CC. A	4	11–16	—	—	—	—	—	—	—	—
CCI. A	2	10–11	—	—	—	—	—	—	—	—
CCII. A	3	8–13	—	—	—	—	—	—	—	—
CCIII. A	3	11–13	—	—	—	—	—	—	—	—
CCIV. A	4	10·5–12·5	—	—	—	—	—	—	—	—
CCV. A	1	13	—	—	—	—	—	—	—	—

Continued.

Scophthalmus norvegicus.		Gobius sp.		Trigla sp.		Trachinus vipera.		Callionymus lyra.		Blennius sp.	
No.	Size.	No.	Size.	No.	Size.	No.	Size.	No.	Size.	No.	Size.
—	—	—	—	—	—	1	7	—	—	1	21
—	—	1	19	—	—	—	—	—	—	—	—
—	—	1	6	2	6·5–7·5	1	5·5	—	—	—	—
—	—	—	—	—	—	1	7	—	—	—	—
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—	—	—	—	—	—	1	5	1	5	—	—
—	—	—	—	—	—	—	—	1	7	—	—
—	—	—	—	2	8–28·5	4	z	11	6–9·5	5	6·5–8
—	—	—	—	2	ca 18	4	5–6·5	—	—	—	—
—	—	—	—	5	5–13	1	6	—	—	1	7
—	—	1	6	3	5–12	3	5–7·5	6	4·5–10	6	6·5–12
—	—	—	—	1	14	1	9	—	—	—	—
—	—	1	5·5	—	—	1	7·5	2	6–8	—	—
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—	—	—	—	2	6–8	1	7	1	7·5	—	—
—	—	3	8–10	3	5–7	4	5–7	6	5·8	—	—
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CONCLUDING REMARKS.

The Tables of the occurrence of the various species with the number and size of individuals show that all those recorded spawn either in the immediate neighbourhood or at localities not far distant.

It may be of interest to note here the capture of the young stages of those adult forms which have approximately their most northern limit of distribution in Plymouth waters.*

The spawning period is definite for most of the species, though in cases such as the sprat and dragonet, it is prolonged indefinitely over a considerable part of the year. In closely related species of the same genus there may be wide variation in the length and time of spawning.

One of the most interesting problems suggested by the study of the distribution of pelagic larval and post-larval forms is the question of the nature of the causes which bring about the movements of young fishes from the inshore to the offshore waters and vice versa. There appears to be evidence in favour of the view that in some localities these movements are the result of inshore and offshore currents which are not constant and which seem to vary according to the prevailing winds. In narrow waters like the English Channel, the currents are doubtless modified by the general set of the main currents from the Atlantic, and by the contour of the coast-line. In addition, the tidal streams tend to make conditions more complex. The present records bring some evidence to bear on the matter. For example, pelagic larval and post-larval forms of *Ctenolabrus rupestris*, an inshore spawner, occurred in the waters south of the Eddystone rocks, while similar stages of *Solea variegata*, a deeper water type, were taken in comparatively shallow areas. The whole question is one of great interest and might well repay further investigation.

The vertical distribution of the young was found to vary considerably during day and night hauls. The latter yielded a much larger percentage of young forms from the surface layers.

Finally, incompleteness in the study of the *Clupeidæ*, *Ammodytidæ*, *Triglidæ*, *Bothinæ*, *Gobiidæ*, and *Bleniidæ* must be acknowledged, but these are now receiving special attention.

REFERENCES.

Ehrenbaum's two volumes on "Eier und Larven von Fischen" in the Nordisches Plankton series, Lief 4, 1905, and Lief 10, 1909, have been used extensively in the present work, both for the description of species and in the references to papers published previous to 1909.

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* Since this paper went to press, the larvæ and post-larvæ of *Serranus cabrilla* have been identified from the 1913 material. I am indebted to Prof. Ehrenbaum for confirmation of my identification.

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Marine Biological Association of the United Kingdom.

Report of the Council, 1913.

The Council and Officers.

Four ordinary meetings of the Council were held during the year, at which the average attendance was 11. A Committee of the Council visited and inspected the Plymouth Laboratory.

The Council has to record with regret the death of three of its Vice-Presidents, Lord Avebury and Dr. A Günther, who had been connected with the Association since its foundation, and Sir John Murray, as well as that of Professor Adam Sedgwick and of Dr. P. L. Sclater, who were both members of the original Council and always took a deep interest in the Association.

The thanks of the Association are due to the Royal Society and to the Linnean Society, in whose rooms the meetings of the Council have been held.

The Plymouth Laboratory.

No important repairs to the building were necessary during the year. As regards the machinery, the small gas-engine which is used for circulating sea-water through the tanks has been fitted with a new piston and cylinder liner, and the arrangements for cooling the engine have been altered. The pumps will soon require some attention, but in other respects the machinery is in an efficient condition. The circulation of sea-water through the tanks has been maintained without any interruption.

The Boats.

The *Oithona* was put in commission in May, and has been working continuously since that time. Mr. E. T. Browne having undertaken to use the vessel in connection with his work on hydroids and medusæ and to pay her expenses during a portion of the winter, the Council has been able to keep the vessel in commission throughout the whole year. This has been a very great advantage in many ways, especially as it has prevented the usual disbanding of the crew for the winter months.

A new sailing-boat has been built to replace the old *Anton Dohrn*, which had done good service for many years. The new boat is a fine sea-boat and well suited for her work.

The small motor-boat given to the Laboratory by Colonel Giles was used during the summer, but she has not proved quite a suitable type of boat for rough work. It is proposed to sell her and replace her by a motor-boat better adapted for dredging and trawling.

The Staff.

The staff remains as last year, with the addition of Mr. E. Ford as Assistant Naturalist. Mr. E. W. Nelson, who left the Laboratory to take part in Captain Scott's Antarctic expedition, has returned to work out the material collected there, and has been made an honorary member of the staff. Mr. Matthews and Mr. Crawshay have spent the greater part of the year in connection with the expedition of the *Scotia*, which was sent out to study the movements of the ice off the Labrador coast. They both took part in the actual expedition, Mr. Matthews being chief of the scientific staff, and they have since been engaged in working up the results of the hydrographical and plankton observations which were made on board. The expedition was organized by the Board of Trade and the principal steamship companies running on the North Atlantic routes, by whom all the expenses were paid.

Occupation of Tables.

The following Naturalists have occupied tables at the Plymouth Laboratory during the year:—

E. AUNAP, Russia (Elasmobranchs).
E. T. BROWNE, B.A., Berkhamsted (Hydrozoa).
Prof. E. L. BOUVIER, Paris (Crustacea).
A. BOWMAN, D.SC., Edinburgh (Fishes).
G. E. BULLEN, St. Albans (Plankton).
J. W. CHALONER, Burnley (Fishes).
W. DE MORGAN, Plymouth (Protozoa).
F. MARTIN DUNCAN, Twickenham (Photography of Marine Animals).
J. GRAY, Cambridge (Electrical Conductivity of Echinus Eggs).
W. O. R. KING, Leeds (Echinus).
Miss D. JORDAN LLOYD, Cambridge (Regeneration).
D. C. MCINTOSH, D.SC., Edinburgh (Echinoderms).
Prof. J. MCMURRICH, Toronto (Anemones).
Mrs. MATTHEWS, Plymouth (Alcyonium).
G. R. MINES, M.A., Cambridge (Heart Rhythm).

Dr. Th. Mortensen, Copenhagen (Echinoderms).
E. W. Nelson, Plymouth (Antarctic Plankton).
F. A. Potts, Cambridge (Polychætes).
L. N. G. Ramsay, Cambridge (Nereids).
R. W. H. Row, London (Sponges).
J. T. Saunders, Cambridge (Alkalinity of Fresh-water and Sea-water).
R. E. Savage, London (Fishes).
Mrs. E. W. Sexton, Plymouth (Amphipoda).
Prof. H. D. Senior, New York (Nervous System of Elasmobranchs).
C. Shearer, m.a., Cambridge (Echinus).
Geoffrey Smith, m.a., Oxford (Crustacea).
Capt. F. H. Stewart, Lahore (Nematodes).
Dr. Nils Svedelius, Upsala (Nitophyllum).
Miss A. W. Thomson, Oxford (Nicothöe).
Dr. Stuart Thomson, Manchester (Brain of Selachians).
H. C. Thornton, Oxford (Hæmosporidia).
A. W. Waters, Bournemouth (Polyzoa).

The usual Easter Vacation Course in Marine Biology was conducted this year by Mr. F. A. Potts, m.a., and was attended by twenty-one students. Mr. J. T. Cunningham, m.a., brought a class of five students from the South-Western Polytechnic, Chelsea, at Whitsuntide.

General Work at the Plymouth Laboratory.

Considerable progress has been made with the different researches upon which the scientific staff has been employed. A number of reports upon this work were published in the Journal (Volume X, No. 1) issued during the year, and still further reports are now in the press and will be published immediately.

Mr. R. S. Clark, who is carrying out investigations on fishes and fishery questions, was engaged during the early part of the year in studying the spring mackerel fishery carried on off the west coast of Cornwall. The season was in some ways unfortunate, as the fishery was for the most part abnormally bad. Nevertheless observations made during such a season are not without value, since they yield useful material for comparison with years when the fish are abundant. By examining the stomach contents of fishes caught with lines and trawls, Mr. Clark was successful in obtaining evidence of the presence of mackerel near the bottom in places where the fishermen were unable to capture any at the surface.

After the *Oithona* was put in commission in May, Mr. Clark devoted his time to the collection of larval, post-larval and young stages of fishes occurring in the neighbourhood of Plymouth. These were captured by means of the Petersen young-fish trawl and with large tow-nets, and a very extensive collection was made. The collection has since been studied and a detailed report upon it, including a number of illustrations of different stages in the life-histories of the fishes, is in the press.

Mr. Orton has continued to study the modes of feeding and the rate of growth of invertebrates. The growth rate of many species has been determined by fixing in convenient positions in Plymouth Sound various objects, such as shells, tiles and pieces of wood, and measuring the growth of the different animals which attach themselves to these objects. Similar measurements have been made of animals growing on marked objects put on the bottom in the Sound and subsequently dredged up. The growth of many of these fixed species has been shown to be surprisingly rapid, and frequently several generations may be produced in the course of a year. A preliminary report on the subject is in the press.

The Director has continued his experiments upon the growth of plankton diatoms under laboratory conditions, which have been referred to in previous reports, and a paper on the subject is in course of preparation. The Director has also been continuing his studies of the marine annelids of the Plymouth area, and a number of new records have been added to the local fauna.

The trustees of the "Ray Lankester Fund," established by Mr. G. P. Bidder, elected Professor E. L. Bouvier of the Natural History Museum at Paris as the first "Ray Lankester Investigator." Prof. Bouvier arrived at the Laboratory in July and remained until the end of August, the special object of his work being to study the life-history of the sea-crayfish (*Palinurus vulgaris*). One of the most interesting stages in the later larval development of this animal, the *puerulus*, which was known to occur in many foreign species of the genus Palinurus, had never been observed in the case of the common European form. This, as well as nearly all the earlier stages, was obtained by pelagic fishing with the young-fish trawl in the neighbourhood of the Eddystone. Prof. Bouvier also obtained specimens of the interesting crustacean larva Trachelifer, which had not previously been recorded from the English Channel.

Dr. Mortensen, of Copenhagen, worked during the summer at the development of Echinoderms, and has published a paper in the Journal of the Association containing descriptions of a number of larvæ belonging to this group, which he had obtained by fertilizing the eggs and rearing the larval stages in the Laboratory.

Some interesting experimental work on the electrical conductivity of Echinus eggs was carried out by Mr. J. Gray, and a preliminary account of his experiments has been published in the Journal.

Dr. C. Shearer has continued his work on the hybridization of different species of Echinus, and during the year a detailed memoir containing an account of the previous work on this subject carried out by Dr. Shearer, Mr. De Morgan, and Mr. Fuchs, has been published in the Philosophical Transactions of the Royal Society.

Mrs. Matthews has continued her work on the development of Alcyonium, and has succeeded in obtaining and studying all stages in the development of this form.

Mr. W. De Morgan has been studying the protozoan fauna of Plymouth, especially the ciliates found in the Laboratory tanks.

Dr. Stuart Thomson spent three months at the Laboratory during the summer, which he devoted to researches on the anatomy of the brain of Elasmobranchs.

The Library.

The thanks of the Association are due for the following books and current numbers of periodicals presented to the Library during the year:—

Académie Imp. des Sciences de St. Pétersbourg. Bulletin.
Academy of Natural Sciences, Philadelphia. Journal.
American Microscopical Society. Transactions.
American Philosophical Society. Proceedings.
American Museum of Natural History. Annual Report.
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—— Monthly Return of Sea Fisheries, England and Wales.
—— Report of Proceedings of Annual Meeting.
Biochemical Bulletin.
British Association for the Advancement of Science. Report.
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The Fisherman's Nautical Almanac. By O. F. Olsen.

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Donations and Receipts.

The receipts for the year include the grants from His Majesty's Treasury (£1000) and the Board of Agriculture and Fisheries Development Fund (£500), Fishmongers' Company (£800), Special Donations (£280), Composition Fees (£47), Annual Subscriptions (£147), Rent of Tables in the Laboratory (£151), Sale of Specimens (£516), Admission to Tank Room (£130).

Vice-Presidents, Officers, and Council.

The following is the list of gentlemen proposed by the Council for election for the year 1914–15:—

President.

Sir E. RAY LANKESTER, K.C.B., LL.D., F.R.S.

Vice-Presidents.

The Duke of BEDFORD, K.G.
The Earl of DUCIE, F.R.S.
The Earl of STRADBROKE, C.V.O., C.B.
Lord MONTAGU OF BEAULIEU.
Lord WALSINGHAM, F.R.S.
The Right Hon. A. J. BALFOUR, M.P., F.R.S.
The Right Hon. JOSEPH CHAMBERLAIN, M.P.
The Right Hon. AUSTEN CHAMBERLAIN, M.P.
W. ASTOR, Esq., M.P.
G. A. BOULENGER, Esq., F.R.S.
A. R. STEEL-MAITLAND, Esq., M.P.
Rev. Canon NORMAN, D.C.L., F.R.S.
EDWIN WATERHOUSE, Esq.

Members of Council.

- E. T. Browne, Esq.
- L. W. Byrne, Esq.
- Prof. H. J. Fleure, D.Sc.
- Sir Eustace Gurney.
- Commander M. W. Campbell Hepworth, C.B., R.N.R.
- Prof. J. P. Hill, D.Sc., F.R.S.
- E. W. L. Holt, Esq.
- Prof. E. W. MacBride, D.Sc., F.R.S.
- H. G. Maurice, Esq.
- Dr. P. Chalmers Mitchell, F.R.S.
- F. A. Potts, Esq.
- Edgar Schuster, Esq., D.Sc.
- Geoffrey W. Smith, Esq.
- Prof. D'Arcy W. Thompson, C.B.

Chairman of Council.

A. E. Shipley, Esq., D.Sc., F.R.S.

Hon. Treasurer.

J. A. Travers, Esq., Tortington, Arundel.

Hon. Secretary.

E. J. Allen, Esq., D.Sc., The Laboratory, Citadel Hill, Plymouth.

The following Governors are also members of the Council:—

- G. P. Bidder, Esq.
- Major-General W. E. Blewitt, C.B., C.M.G. (Prime Warden of the Fishmongers' Company).
- The Earl of Portsmouth (Fishmongers' Company).
- Sir Richard Martin, Bart. (Fishmongers' Company).
- The Hon. Nathaniel Charles Rothschild (Fishmongers' Company).
- Prof. G. C. Bourne, D.Sc., F.R.S. (Oxford University).
- A. E. Shipley, Esq., D.Sc., F.R.S. (Cambridge University).
- Prof. W. A. Herdman, D.Sc., F.R.S. (British Association).

THE MARINE BIOLOGICAL ASSOCIATION

Dr. *Statement of Receipts and Payments for*

				£	s.	d.	£	s.	d.
To Balance from Last Year :—									
Cash at Bankers				135	11	10			
Cash in hand				10	5	10	145	17	8
To Current Receipts :—									
H.M. Treasury for year ending 31st March, 1914				1,000	0	0			
The Worshipful Company of Fishmongers (including £200 attributable to 1912)				800	0	0			
Annual Subscriptions received				146	19	0			
Rent of Tables (including Ray Lankester Trustees, £20 ; University of Cambridge, £25 ; University of London, £25)				151	12	0			
Composition Fees				47	5	0	2,145	16	0
,, Extraordinary Receipts :—									
Donations—									
"Anonymous"	200	0	0						
Dr. C. Shearer (part payment as Founder)	75	18	9						
Professor G. C. Bourne	3	19	0						
G. H. Fox	0	10	6	280	8	3			
Board of Agriculture and Fisheries, Grant from Development Fund, for year ending 31st March, 1914				500	0	0	780	8	3
							£3,072	1	11

The Association's Bankers hold on its behalf £410 14s. 8d. New Zealand 4 % Stock, 1943–63.

OF THE UNITED KINGDOM.

the Year ending 31*st December*, 1913. Cr.

				£	s.	d.	£	s.	d.
By Salaries and Wages—									
Director				309	3	2			
Hydrographer				16	13	4			
Senior Naturalist				199	5	4			
Second Naturalist				189	17	8			
Additional Naturalist				28	11	4			
Assistant Naturalists				32	1	5			
Salaries, Wages, and Compensation				701	2	10			
				1,476	15	1			
Less Compensation recovered from Employers' Liability Corporation				16	5	11	1,460	9	2
,, Travelling Expenses							81	13	7
,, Library				179	11	1			
Less Duplicates sold				0	8	10	179	2	3
,, Journal				130	10	5			
Less Sales				19	6	1	111	4	4
,, Buildings and Public Tank Room—									
Gas, Water, and Coal				122	19	10			
Stocking Tanks and Feeding				24	3	5			
Maintenance and Renewals				95	16	11			
Rent, Rates, Taxes, and Insurance				76	14	10			
				319	15	0			
Less Admission to Tank Room				130	7	11	189	7	1
,, Laboratory, Boats, and Sundry Expenses—									
Glass, Apparatus, and Chemicals				208	15	3			
Purchase of Specimens				80	8	4			
Maintenance and Renewal of Boats, Nets, etc.				361	4	3			
Insurance of s.y. *Oithona*, *less* Rebate				9	14	0			
Coal and Water for Steamer				120	5	6			
Stationery, Office Expenses, Carriage, Printing, etc.				142	7	1			
				922	14	5			
Less Sales of Apparatus	85	12	2						
,, Specimens	516	4	0						
,, Nets, Gear, etc.	144	12	5						
Hire of Boat and Gear	70	16	2	817	4	9	105	9	8
,, Purchase of £410 14s. 8d. New Zealand 4% Stock							400	0	0
,, Balance:—									
Cash at Bankers				540	13	4			
Cash in hand				4	2	6	544	15	10
							£3,072	1	11

Examined and found correct.
28*th January*, 1914.

(Signed) N. E. Waterhouse.
L. W. Byrne.
J. O. Borley.
W. T. Calman.

On the Culture of the Plankton Diatom *Thalassiosira gravida* Cleve, in Artificial Sea-water.

By

E. J. Allen, D.Sc., F.R.S.,

Director of the Plymouth Laboratory.

In a former paper,* written in conjunction with my colleague Mr. E. W. Nelson, the conditions under which a rapid and continuous growth of marine plankton diatoms can be obtained in laboratory cultures were discussed. It was pointed out that when natural sea-water is used as the basis of the culture media we are dealing with a solution of a very complex and variable character, the exact nature of which it is extremely difficult to determine, and that the ideal to be aimed at is to find a culture medium with artificially prepared sea-water as its basis, such that the absence or diminution in quantity of any one of its constituents would have a profound effect upon the growth of diatoms in it. A reference was made (*loc. cit.*, p. 446)† to some experiments with artificial sea-water, which, whilst pointing to the probability of successful work being possible on these lines, were in themselves too uncertain to be satisfactory.

Experiments in this direction have been continued at intervals during the past three years, and although the problem has not been completely solved the results obtained seem to be of sufficient interest and importance to warrant publication in their present incomplete form, more particularly because points remaining to be cleared up probably require a knowledge of the chemistry of organic compounds to which I cannot lay claim.

Stated in general terms the most interesting result so far obtained is that in the artificial sea-water tried, made by dissolving Kahlbaum's pure chemicals in doubly distilled water, little or no growth of diatom (*Thalassiosira gravida* Cleve) takes place, but if to this artificial sea-water as little as 1 per cent of natural sea-water is added vigorous and large cultures are obtained, and with an addition of about 4 per cent of natural sea-water from the Laboratory tanks better cultures result than have so far been got in any medium which has natural instead of artificial sea-water as a basis.

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* Allen, E. J., and Nelson, E. W. "On the Artificial Culture of Marine Plankton Organisms," *Journ. Mar. Biol. Assoc.*, VIII, 1910. Also in *Quart. Journ. Micr. Sci.*, Vol. LV, 1910. The two papers are identical.

† *Q.J.M.S.*, Vol. LV, p. 393.

THE DIATOM CULTURE USED.

A culture of the diatom *Thalassiosira gravida* Cleve, isolated some years ago,* which has been kept since then by successive inoculations in fresh culture medium, has been used almost entirely for these experiments. This species is especially useful owing to the fact that in healthy cultures the cells hang together in long chains, whereas when the culture is unhealthy or becoming exhausted the chains break up. This is a most useful guide when watching the progress of an experiment.

The Purity of the Culture.—The culture contains no other diatom except *T. gravida* and no other organisms except bacteria. It would of course be preferable, if it were possible, to remove all the bacteria, so as to deal with a perfectly pure culture of the diatom. Many attempts have been made to attain this end, but so far without complete success, though it has been possible to carry the process of purification so far that only one species of bacterium capable of forming colonies on a peptone-agar plate† was at all abundant. The method adopted for purifying the culture was that of differential poisoning, a suitable poison being added to a number of culture flasks in a series of gradually diminishing strengths, in the hope that one strength might be found which would kill the bacteria without killing the diatom.

A measure of success was obtained with Copper sulphate in this way. In the most successful case a solution of the salt was added to 100 c.c. of culture medium containing *Thalassiosira gravida* in such proportion that the 100 c.c. contained ·001 grams of $CuSO_4\ 5H_2O$. After an interval of twelve minutes a fresh flask containing 100 c.c. of culture medium was inoculated with 1 c.c. from the first one. In the second flask a very fine growth of diatoms appeared, which was much more healthy and vigorous than untreated cultures, and contained far fewer bacteria, as shown by peptone-agar plates.

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* Allen and Nelson, *loc. cit.*, p. 460. [*Q.J.M.S.*, p. 412.] The species was then thought to be a variety of *Thalassiosira decipiens*. Subsequent examination by Mr. Nelson has convinced him that it is really *Th. gravida*. The extreme delicacy of the siliceous skeleton of these diatoms makes the determination of species founded chiefly on valve structure very difficult. The species was formerly thought to be a variety of *Thalassiosira decipiens* Grun. since the only markings that were observed were characteristic of this species, although no markings at all could be resolved with the great majority of valves. Examination of the present cultures by Mr. Nelson with more perfect apparatus has shown the typical *Th. gravida* Cleve valve structure to which species this form is now referred. It is not unlikely that the older cultures were a mixture of *Th. decipiens* and *gravida* from which the *decipiens* have died out.

† It should be remembered that possibly the presence of some bacteria in the cultures is necessary for their success, though Miquel (*Le Diatomiste*, I, 1890-3, pp. 153-6) states definitely that he obtained cultures of fresh water diatoms which were entirely free from bacteria, and Richter (*Ber. deut. bot. Gesell*, XXI, 1903 and later papers) also succeeded in obtaining such bacteria-free cultures on solid culture media.

Still better results were got, however, by a method which was first recommended to me by Mr. D. J. Matthews, who had made use of it for destroying bacteria in aquarium water. This consists in passing an electric current through the sea-water between carbon poles, until a considerable formation of hypochlorous acid has taken place and the water smells strongly of chlorine. The following description of an experiment will show how the method was applied in the case of the diatom cultures.

Experiment 449.—2½ litres of sea-water from the Laboratory tanks, which had been treated with animal charcoal and filtered through a Berkefeld filter, were put in a sterilized square glass jar, and an electric current varying from 1·7 to 1·5 ampères was passed through it for three minutes, two carbon plates* (sterilized by heating) being used as poles, the plates being constantly moved as the current was passing. The electrolysed water then smelt strongly of chlorine. It was allowed to stand for one hour, and then 50 c.c. of it was added to a flask (*x*), which contained 50 c.c. of unelectrolysed Berkefeld water,† to which had been added a quantity of *Thalassiosira gravida* from the culture which was to be cleansed.

Sixteen flasks (*a*–*q*) had previously been made ready, each containing about 75 c.c. of sterile culture medium (outside sea-water treated with Miquel's solutions and boiled). After the electrolysed water had been in contact with the *Thalassiosira* for thirty-one seconds about ½ c.c. from flask *x* was added to flask *a*, and similar amounts were added to the remaining flasks *b*, *c*, *d*, etc., at intervals of about ten seconds for the first two minutes, and then at longer intervals until the last flask *q* was inoculated after the *Thalassiosira* had been in contact with the electrolysed water for four minutes.

In this way a series of culture flasks was obtained inoculated with *Thalassiosira* which had been in contact with electrolysed water for varying times. The flasks were placed in a suitable position before a north window and the diatoms allowed to develop. At the end of a week the first flasks in the series (*a*, *b*, *c*, etc.) showed good growth, the later ones

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* The size of each plate was 120 × 44 × 6 mm.

† See Allen and Nelson, *loc. cit.*, p. 432 [*Q.J.M.S.*, p. 375].

(*m–q*) showing little or none. At the end of three weeks the result was quite different, for whilst the early flasks showed only moderate growths and were already beginning to go off, a sure sign of contamination, two amongst the later ones (*m* and *o*) showed very fine growths of a rich brown colour and forming very long chains. The culture in flask *o* was one of the best and most vigorous that I have obtained during the whole course of my experiments, and sub-cultures from it remained excellent for many months.

The following table shows for the last few flasks of the series the times that the *Thalassiosira* remained in the electrolysed water, and the kind of growth that was obtained :—

Flask.	Time during which *Thalassiosira* was in electrolysed water.	Result culture.
l.	2 min. 28 secs.	Moderate culture, not persisting very long.
m.	2 min. 43 secs.	Very good culture, with long chains, second best of series.
n.	3 min. 0 secs.	No growth of *Thalassiosira.*
o.	3 min. 22 secs.	Very fine culture, best of series, dark brown colour and very long chains. Remained good for a long time and gave a long series of good sub-cultures.
p.	3 min. 40 secs.	No growth of *Thalassiosira.*
q.	4 min. 0 secs.	No growth of *Thalassiosira.*

(Flasks *a–k* all gave moderate growths which did not persist, with the exception of flask *h* (1 min. 44 secs.), which had no growth.)

Peptone-agar plates inoculated with 1 c.c. from flask *o* showed bacteria of two kinds only, a few large yellow colonies, and many minute, slow-growing colonies. They were of quite a different character from plates made from ordinary cultures of *Thalassiosira*, which were always crowded with yellow colonies, mixed with a large number of large milk-white colonies which liquefied the agar, both kinds of colonies developing very rapidly.

After some experience it becomes easy to distinguish a clean culture of *T. gravida* from one which is much contaminated by bacteria, by the character and progress of the growth. In a clean culture, at any rate during the summer months when the light conditions are favourable, the growth is much more rapid and vigorous, the tendency to form long chains is very great, especially at first, the colour is a deep rich brown, and healthy growth in a flask will go on for months. In a contaminated culture, on the other hand, growth is slower and only quite short chains are seen, the colour is a much lighter brown, and the culture does not continue to grow in a healthy way, generally forming auxospores and often dying off altogether in the course of two or three weeks.

All the main conclusions detailed in this paper have been confirmed with clean and healthy cultures. Experiments with contaminated cultures are not, however, without value, since they sometimes emphasize the differences between culture media that it is desired to compare, a contaminated culture often failing to grow at all in an unfavourable medium, whereas a clean culture might give a growth, less in amount, it is true, but not much different in character from the growth in the control culture in a favourable medium.

THE ARTIFICIAL WATER.

The artificial sea-water used in the experiments was made by dissolving Kahlbaum's pure chemicals in ordinary distilled water made in a copper still which had been redistilled in all-glass apparatus after being treated with bichromate of potash and sulphuric acid, to destroy volatile organic matter. This double distilled water contained at most 0·01 mg. of ammonia per litre.[*]

The composition of the water was based on the analysis of sea-water published by Dittmar in the "Challenger" Reports.[†] The figures given by Dittmar are :—

	Per 100 parts halogen.
Cl	99·848
Br	·3402
SO_3	11·576
CO_2	·2742
CaO	3·026
MgO	11·212
K_2O	2·405
Na_2O	74·462

Dividing these figures by the respective molecular or atomic weights, and treating those for Cl and Br together as chlorine, we get after reducing Na_2O to 100, the following figures, which give the relative number of molecules or atoms :—

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[*] In connection with the preparation of the artificial sea-water I received constant help and advice from my colleague, Mr. D. J. Matthews. Without his ready assistance in connection with all chemical questions this investigation could hardly have been carried out.

[†] "Challenger" Report, Chemistry, Vol. I, p. 203.

Na_2O	100
K_2O	2·130
MgO	23·104
CaO	4·499
CO_2	0·519
SO_3	12·048
Cl	234·54

which gives the following molecular proportions for the bases and radicals separately :—

Na	100·0
K	2·13
Mg	11·55
Ca	2·25
CO_3	0·259
SO_4	6·024
Cl	117·27

If we use solutions of salts containing a gram molecular weight per litre, since 1 c.c. of each solution contains the same number of molecules, the relative number of c.cs., keeping the proportional amounts of the bases, the CO_3 and the SO_4 as above, and making the remainder chlorine, will be :—

NaCl	99·58
KCl	2·13
$CaCl_2$	2·25
$MgCl_2$	5·53
$MgSO_4$	6·02
Na_2CO_3	0·26

Since these figures give the number of molecules of *Na* somewhat too high, it was thought better to use 0·26 c.c. of sodium bicarbonate ($NaHCO_3$) instead of the normal carbonate, and this has been done throughout.

In making up artificial sea-waters it has been found most convenient to prepare first of all gram molecular solutions of each of the above salts and then to mix these in the proportions indicated. These molecular solutions are easily prepared and the strengths of the chlorides compared and corrected by titrating them with silver nitrate.

The following details of the preparation of the molecular solutions may be of assistance to future workers :—

Msol. NaCl.	Kahlbaum's "Sodium chloride for Analysis." 58·5 grams dissolved in double-distilled water, and brought to 1000 c.c. at 15°C.
Msol. KCl.	Kahlbaum's "Potassium chloride." 74·5 grams dissolved in double-distilled water and brought to 1000 c.c. at 15°C.
Msol. $CaCl_2$.	Kahlbaum's "Calcium chloride cryst. for Analysis." About 300 grams were dissolved in about 1 litre of double distilled water. On titration with silver nitrate solution 2 c.c. of the above $CaCl_2$ solution required 30·3 c.c. of $AgNO_3$. 2 c.c. of Msol. KCl required 8·34 c.c. $AgNO_3$, so that 2 c.c. of Msol. K_2Cl_2 would require 16·68 c.c. $AgNO_3$. The $CaCl_2$ solution is therefore too strong in the proportion $\frac{30·3}{16·68} = 1·8166$. In order to get the Msol. $CaCl_2$ 1000 c.c. of the strong solution prepared must be diluted to 1816·6 c.c. This was done and the final solution again titrated against the Msol. KCl.
Msol. $MgCl_2$.	Kahlbaum's "Magnesium Chloride for Analysis." As in the case of $CaCl_2$ a strong solution was first prepared, titrated with $AgNO_3$ and diluted with double-distilled water to the required extent, Msol. KCl being used as standard.
Msol. $MgSO_4$.	Kahlbaum's "Magnesium Sulphate for Analysis." Crystallized magnesium sulphate has the formula $MgSO_4$ $7H_2O$, the molecular weight of which is 246·4. To make the molecular solution 246·4 grams of the salt were dissolved in double-distilled water and brought to 1000 c.c. at 15°C.
Msol. $NaHCO_3$.	Kahlbaum's "Sodium Bicarbonate for Analysis." 84 grams dissolved in double-distilled water and brought to 1000 c.c.

In order to prevent the growth of moulds in the stock solutions these were all brought to the boil and kept in sterilized glass-stoppered bottles, the stoppers being tied down with a cap of parchment paper which was taken directly out of boiling water. When any of the solution was used, the parchment cap was removed and placed in boiling water, the bottle was carefully opened and the amount of solution required poured out, the stopper being quickly replaced and tied down. These precautions are important, as the growth of mould in the solutions may have an important influence on the diatom cultures.

It has generally been found most convenient to make up the sodium chloride solution, of which large quantities are required, as it is wanted, and not to store it.

In the last table above the relative amounts (c.cs. of M solutions) of the different salts required to prepare the artificial sea-water are given. There remains to consider the actual salinity of the water which we are to employ, which is generally expressed as the weight in grams of the total salts contained in 1000 grams of the water. The salinity of natural sea-water in the western portion of the English Channel generally varies from about 35·5 to 35·0 per thousand, the water being generally lower in salinity near the coast. In laboratory experiments the water in the flasks becomes progressively more concentrated owing to evaporation, and a low salinity has therefore been adopted for the artificial sea-water used, namely, 35·0 per thousand.

The following table gives the composition of an artificial sea-water having a salinity of 35 per thousand, and with the salts in the relative proportions obtained above from Dittmar's analysis. The composition is stated (1) as the number of cubic centimetres of gram molecular solution contained in 1000 c.c. of the artificial water, and (2) as the number of grams of each salt contained in 1000 c.c.

	c.cs. of M. solution contained in 1 litre.	Grams per litre.
$NaCl$	480·80	28.13
KCl	10·28	0·77
$CaCl_2$	10·86	1·20
$MgCl_2$	26·70	2·55
$MgSO_4$	29·06	3·50
$NaHCO_3$	1·25*	0·11

To make up a litre of artificial sea-water the simplest procedure is therefore to weigh out 28·13 grams of sodium chloride, dissolve it in about half a litre of double-distilled water placed in a 1 litre flask, add the requisite number of cubic centimetres of M solutions of the other salts (KCl 10·28, $CaCl_2$ 10·86, etc.) and then make the whole up to exactly 1 litre by adding double-distilled water.

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* 2·6 c.c. was the amount generally used, as the increased alkalinity is favourable to diatom growth. See below.

Water prepared according to the figures given in this table was titrated for me by Mr. Matthews against the standard water supplied by the International Council, and was found to have a salinity of 35 per thousand.

Alkalinity.—The alkalinity has also been compared with that of sea-water from outside the Plymouth Breakwater by Sorensen's method, and was found to be very close to it, the artificial water being slightly less alkaline. It was found experimentally that better growths of diatoms were obtained when the alkalinity was increased somewhat,* the best result being obtained when an extra 1·33 c.c. of Msol. $NaHCO_3$ per litre was added, making a total of 2·6 c.c. of the molecular solution of this salt.

DIATOM CULTURES IN ARTIFICIAL SEA-WATER.

As was to be expected, it is not possible to obtain cultures of diatoms in the artificial sea-water prepared as described in the last section as it stands. The water must be first treated with nutritive solutions, and for this purpose the modifications of Miquel's solutions described in our former paper† have been used. Two solutions are employed as follows :—

Solution A.

Potassium nitrate 20·2 grm.
Distilled water to 100 c.c. } $=2M\ KNO_3$.

Solution B.

Sodium phosphate ($Na_2HPO_412H_2O$)	4 grm.
Calcium chloride ($CaCl_26H_20$)	4 ,,
Ferric chloride (melted)	2 c.c.
Hydrochloric acid (pure, concentrated)	2 c.c.
Distilled water	80 c.c.

To each 1000 c.c. of artificial water add 2 c.c. solution A and 1 c.c. solution B. Sterilize by bringing to the boil. When cool decant‡ off the clear liquid from the precipitate which is formed on the addition of solution B. The clear liquid is referred to in what follows under the name "artificial miqueled water."

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* Cf. Allen and Nelson, *loc. cit.*, p. 452 [*Q.J.M.S.*, p. 401]. The figure here given was derived from later experiments.

† Allen and Nelson, *loc. cit.*, p. 428 [*Q.J.M.S.*, p. 370]. For details as to the preparation of Solution B that paper or Miquel's original account should be studied.

‡ Filter papers should not be used to filter off the precipitate. They appear to contain some substance which inhibits the growth of the cultures. The cultures were made in wide-mouthed spherical glass flasks covered with glass capsules. Cotton wool plugs were not used, as these were found to be injurious to the growth of the diatoms.

It was found, however, that even after the addition of these two solutions very slight growth, if any, took place on inoculating with a small quantity (say one drop) of healthy *Thalassiosira gravida* culture. This was the case even after the addition of potassium bromide and iodide, or of Miquel's own solution A, which contains these two salts. If, on the other hand, the artificial miqueled water was inoculated with *a considerable quantity* of a culture of *Thalassiosira* in which natural sea-water had formed the basis of the culture medium, so that a considerable quantity of this natural water was transferred to the artificial medium, then the latter would develop a fine healthy growth. Experiences of this kind led me to suspect that the irregularities which had previously been met with in trying to make cultures in artificial media* might be due to varying amounts of natural sea-water introduced when inoculating. Definite experiments were therefore undertaken in order to ascertain whether the addition of natural sea-water to the artificial miqueled water would make it effective as a culture medium, and if so what proportion of natural sea-water was essential. *In all cases the culture medium was boiled after the addition of the natural sea-water and then allowed to cool before inoculation.*

As a result of these experiments it was shown that an addition of even 1 per cent of natural sea-water to the artificial miqueled water was sufficient to give very heavy cultures after inoculation with only one drop of *Thalassiosira* culture, and that with an addition of 4 per cent of natural sea-water better cultures were obtained than in any other culture medium known to me. This result has now been obtained so many times that it is in my opinion quite definitely established. If the proportion of natural sea-water added is reduced below 1 per cent smaller growths are obtained, and it is somewhat difficult to decide whether there is a definite minimum below which no growth takes place. An addition of 0·3 per cent of natural sea-water in one satisfactory experiment produced quite a heavy growth, whereas without this addition only a small growth was obtained. It has often been observed that whilst flasks containing 75 c.c. of artificial miqueled water show distinct signs of diatom growth when inoculated with one or two drops of a culture of *Thalassiosira* in natural sea-water, such flasks inoculated with one or two drops of a culture which has artificial sea-water as the basis of the culture medium show practically no signs of growth at all, and remain quite clear. Since the above conclusions were reached it has been my practice in critical experiments always to inoculate from a culture in the artificial medium, so as to reduce the amount of natural water carried over on inoculation to a minimum.

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* Allen and Nelson, *loc. cit.*, p. 447 [*Q.J.M.S.*, p. 394].

From what has been said it seems clear that there is in natural sea-water some substance (or substances) not contained in the artificial water treated with Miquel's solutions, minute traces of which are essential to the growth of *Thalassiosira*. That the quantity present in the culture flasks after the addition of even 4 per cent of natural sea-water must be extremely minute is obvious from the fact that all substances which are present in natural sea-water in quantities beyond a mere trace are contained in the artificial culture medium. It becomes a matter of great interest and perhaps also of great importance to endeavour to find out what this substance may be, of which such exceedingly minute traces make all the difference between practically no growth at all and a vigorous and continued development of the diatoms, for the growths once started may go on increasing rapidly and healthily for several months.

The addition of many substances, both organic and inorganic, to the artificial miqueled water has been tried, generally in several concentrations, but up to the present no definite chemical compound has been found which can take the place of the 1 per cent of natural sea-water.

Of inorganic substances the following have been tried in different concentrations without result: Potassium bromide, potassium iodide (alone and with bromide), gold chloride, potassium nitrite, aluminium chloride, strontium chloride, lithium chloride and lithium carbonate.

It may be suggested that silica is the missing substance, but this seems precluded from the fact that all the experiments have been carried out in glass vessels, and the amount of silica which would go into solution from the glass would certainly be greater than that contained in the added 1 per cent of natural sea-water. Richter * has shown that diatoms grown in glass vessels obtain the silica they require from the glass.

In the course of the experiments it was found that the addition to the artificial miqueled water of a small percentage of sea-water from the tanks of the Plymouth Laboratory gave distinctly better cultures than the addition of the same percentage of natural sea-water brought in from outside. This comparison has been repeated a great many times, and the difference has been so marked and constant that I am compelled to regard it as firmly established. Different samples of sea-water brought in from outside also appear to give somewhat different effects, and, although the experiments have not given sufficiently uniform results to justify a definite statement, I am left with the impression that on the whole samples of water taken from Plymouth Sound, when added to the artificial medium, give better growths than are obtained with samples from the English Channel in the neighbourhood of the Eddystone.

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* Richter, O., *Verh. d. Gesell. deut. Naturf. u. Ärzte.*, Breslau, II, 1904, and *S.B.K. Akad. Wiss. Wien.*, CXV, 1906.

Now the tanks at the Plymouth Laboratory are worked on a closed system of circulation, the same water being circulated over and over again, so that the principal difference between the water taken from them and that obtained from outside consists in the greater abundance in the tank water of organic compounds, which result from the metabolism of living organisms. Is it the presence of some organic substance that is necessary for the growth of the diatoms ? A very large number of experiments have been made with a view to obtaining some light upon this question, and some of these will now be referred to.

Ulva infusion. A small piece of green seaweed (about 1 square cm. of *Ulva latissima*) was boiled for about five minutes in a flask containing 75 c.c. of artificial miqueled sea-water, and was then removed with a sterile platinum needle. In this way a weak organic infusion was obtained. When cold the flask was inoculated with one or two drops of *Thalassiosira* from a culture in artificial water. In this organic infusion a good growth was obtained, nearly equal to that in the control in artificial miquel plus 4 per cent of tank water. This experiment was repeated a number of times with a similar result.

Though it is most probable that the result is due to some organic compound the experiment is, of course, not conclusive, as an inorganic salt may have been dissolved from the ulva. In any circumstances we obtain no hint as to the nature of the organic substance, and the result remains indefinite.

It may be pointed out that Miquel* in his account of his original experiments on diatom cultures, insists upon the value of the addition of some organic infusion or maceration to his culture solutions.

Ulva Extract. A piece of *Ulva latissima* was washed in several changes of artificial sea-water and then an extract was made in absolute alcohol at a temperature of 58° C. The alcohol was evaporated to dryness on a water-bath. 75 c.c. of artificial miqueled sea-water was then boiled in small portions at a time in the vessel containing the extract, so that all soluble parts of the extract were dissolved. The water was then returned to a culture flask, which, when cold, was inoculated with *Thalas-*

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* *Le Diatomiste*, I, 1890–3, p. 95.

siosira, as described in the experiment with ulva infusion. No growth was obtained in the flask.

Ulva Ash. A piece of ulva measuring about 5 cm. by 3 cm. was washed in several changes of double-distilled water. It was then put in a porcelain crucible, dried and heated over a bunsen burner till it was reduced to a white ash. The ash was added to a flask containing 75 c.c. of artificial miqueled sea-water, which was boiled, allowed to cool and inoculated with *Thalassiosira*, as in the two previous experiments. The result of the experiment was again negative.

Experiments with Hemimysis. In order to test whether the products of animal metabolism could immediately supply the substance sought for, the following experiment was carried out with *Hemimysis lamornæ* Couch, a small crustacean which lives in numbers in the Laboratory tanks. In the first experiment (Exp. 404) four *Hemimysis* were passed through two changes of Berkefeld filtered water, the animals being placed on a piece of filter paper to remove surplus fluid before being placed in each change of water. They were then passed in a similar way through two changes of artificial miqueled sea-water (75 c.c. was used altogether, being divided into two portions), and finally placed in a fresh quantity of the artificial miqueled sea-water (75 c.c.). They remained healthy and active and deposited a considerable amount of fæces on the bottom of the vessel. After they had been in the water four hours the *Hemimysis* were taken out and the water placed in a culture flask and brought to the boil. A control experiment with 75 c.c. artificial miqueled sea-water to which 3 c.c. of tank water had been added was set up and brought to the boil in the same way. On the following day both flasks were inoculated with two drops of a *Thalassiosira* culture. During the first week there was a very small growth of diatoms in the flask with the water in which the *Hemimysis* had been, which died out during the next few days. This growth was similar to that which usually occurs in artificial miqueled water to which nothing has been added. The control experiment to which 3 c.c. tank water had been added gave a very fine growth from the first, which persisted for at least five months. The result of this experiment was therefore negative. In another experiment, carried out in other respects in practically the same way, the *Hemimysis* were allowed to remain living in the water for twenty-four hours before they were removed. The result was again negative.

In a third experiment five *Hemimysis* lived for nineteen hours in 75 c.c. artificial miqueled sea-water to which 3 c.c. of tank water had been added. The animals were removed, the water boiled, and when cold inoculated as before with *Thalassiosira*. A good growth resulted, showing that the animals do not excrete substances which completely inhibit the growth of the diatoms.

Evaporated Tank Water. A number of experiments were made in which a quantity of sea-water from the Laboratory tanks was evaporated to dryness on a water bath, the residue heated to different degrees, treated with strong, pure hydrochloric acid and evaporated two or three times to get rid of the acid, and then redissolved to the original volume in double-distilled water. After being neutralized by the addition of $NaHCO_3$, ·4 per cent of the resulting solution was added to artificial miqueled sea-water, the resulting culture medium being boiled, cooled and inoculated with *Thalassiosira* in the usual way.

The results of these experiments are set out in summary form in the annexed Table A. In each case proper control experiments were set up at the same time, generally one with artificial miqueled sea-water to which nothing was added, and one with the same water to which 4 per cent of tank water was added, and the controls were boiled at the same time as the other flasks of the experiment.

As is seen from the table, five series of experiments were made. In the first (Series A) the salts obtained by evaporating the tank water were heated in a porcelain dish over a bunsen burner, the heating being carried out carefully so that the flame did not actually touch the dish, which never became anywhere near red hot. In Series B the evaporation and heating were done in a platinum basin, which was raised to a dull red heat over a bunsen. In Series C the salts were again evaporated and heated in a porcelain basin and made as hot as they could be with a bunsen burner, the flame of which played directly on the outside of the dish, and was moved about so as to heat different portions in turn. In Series D the salts were heated in a hot-air oven, being kept at a temperature of 164° to 170° C. for an hour. In Series E the heating was again carried out in a hot-air oven, a temperature of from 200° to 237° C. being maintained for two hours.

In Series A, D and E, where the heating of the residue was not excessive, quite good cultures resulted. Although they did not quite come up to the controls in which 4 per cent of tank water was added, they were in every case altogether of a different order from what took place in the controls in artificial miqueled sea-water to which nothing had been added.

In the other two series, B and C, where the degree of heating was much greater, in most cases the culture was an entire failure, and in those

TABLE A, showing the results of experiments, in which 4 per cent of tank water, which had been evaporated, heated, and redissolved, was added to artificial miqueled sea-water. The number of the experiment and date of inoculation are given in each case. The cultures were inoculated with *Thalassiosira gravida*.

Evaporated Tank Water. Date of Preparation and Degree of Heating.							
A. Prepared July 11th, 1912. Heated carefully over bunsen in porcelain basin. It never became red hot.	399. D. 13. VII. 12. Good growth not up to controls.			431. D. 18. XI. 12. Good growth equal to or better than control.	433. A. 8. I. 13. Good growth, not up to controls.	455. A. 22. VIII. 13. Good growth, not up to control.	460. A. 9. IX. 13. Good growth, nearly up to control.
B. Prepared Aug. 29th, 1912. Heated over bunsen in a platinum basin to a dull red heat.	407. L. 31. VIII. 12. No growth.	407. M. 31. VIII. 12. (More alkaline than L.) No growth.	408. E. 4. IX. 12. No growth.	431. E. 18. XI. 12. Small growth, but some good chains.	433. B. 8. I. 13. Good growth, not up to A.	455. B. 22. VIII. 13. Below the control in which nothing was added to the artificial miquel.	460. B. 9. IX. 13. Some growth at first. It then went off entirely.
C. Prepared Sept. 26th, 1912. Heated over bunsen in porcelain basin. Made as hot as possible with the flame playing directly on the outside of the dish.			424. G. 18. X. 12. No growth.	431. F. 18. XI. 12. No growth.	433. C. 8. I. 13. Very small growth.	455 C. 22. VIII. 13. Below control, in which nothing was added to the artificial miquel.	460. C. 9. XI. 13. At first the worst of the series, then a fair growth, but below A, D, and E.
D. Prepared Jan. 2nd, 1913. Heated in an oven to 164°–170° C. for 1 hour.					433. D. 8. I. 13. Moderate, healthy growth, better than B.	455 D. 22. VIII. 13. Good growth not up to A.	460. D. 9. IX. 13. Good growth, nearly as good as control.
E. Prepared Jan. 4th, 1913. Heated in an oven to 200°–237° C. for 2 hours.					433. E. 8. I. 13. Moderate, healthy growth, as D.	455. E. Good growth not up to A.	460. E. 9. IX. 13. Good growth, nearly as good as control.

instances in which some growth was obtained it was distinctly below that of cultures of the former series made at the same time.

A study of Table A can, I think, leave no doubt that the general statement is justified that whatever the substance may be which occurs in tank water and the addition of which to artificial miqueled sea-water enables the latter to support a vigorous diatom growth, that substance may be dried and heated to a moderate degree without greatly impairing its efficacy, whilst if it is heated to too high a temperature its efficacy tends to be destroyed.

The experiments are consistent with the theory that the substance is an organic compound, but one of a very stable kind, which is only decomposed with difficulty.

Addition of organic substances to artificial water. Many experiments have been made by adding organic substances in a number of different concentrations to artificial miqueled sea-water, but by none of these has any marked or constant effect been produced upon the growth of *Thalassiosira*. It will be understood, of course, that such negative results are in no way conclusive, as in a case of this kind the attainment of an exactly correct degree of concentration may be essential, and when one is working quite without clue it is hardly possible to carry out a sufficiently extensive series of experiments with every substance, especially when two or three weeks must elapse before the result of any experiment becomes definite. The following substances have been tried: asparagin, calcium succinate, calcium malate, sodium salicylate, theobronine, leucine, tyrosine * (the three latter alone and together with atropine),† peptone, urea and uric acid. In all cases the result was negative.

Putrified Peptone. An isolated result which I have entirely failed to repeat in spite of many attempts may be worth putting on record as a hint for future work, but no other importance should be attached to it. Starting from the idea that the substance sought for might be one of the ultimate products of the breaking down of organic matter under the influence of bacteria, since it appears to be more abundant in the tank water of the Laboratory than in sea-water from outside, the following experiment was carried out. 100 c.c. of a 1 per cent solution of peptone in artificial sea-water was sterilized by boiling on successive days. When cold it was inoculated by adding two drops of tank water. Under the influence of the bacteria of the tank water putrefaction set in and was allowed to continue for nineteen days. The solution was then again boiled. To 75 c.c. of artificial miqueled sea-water three drops of the putrified peptone solution were added, and the flask boiled, and when cold inoculated with two drops from a culture of *Thalassiosira* in artificial miqueled water plus 4 per cent of outside sea-water. At first the water in the culture flask became milky from the growth of bacteria, but this milkiness gradually disappeared and the diatoms commenced to grow, giving finally an excellent culture which was quite up to the control. I do not think there was any flaw in the actual carrying out of the experiment, but, as already mentioned, a number of attempts to repeat it all gave negative results.

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* In consequence of the work of Thornton and Geoffrey Smith on Euglena (*Proceed. Roy. Soc.*, B., Vol. LXXXVIII, p. 151, 1914) special attention was given to tyrosine, and a large number of different concentrations were tried. Entirely negative results were, however, obtained.

† The use of these three substances alone and with atropine was suggested by the work of H. C. Ross on "Auxetics." See H. C. Ross, *Induced Cell-Reproduction and Cancer*, London, J. Murray, 1910; *Further Researches into Induced Cell-Reproduction and Cancer*, I and II, London, J. Murray, 1911 and 1912.

A final point may be mentioned, which also seems to suggest some organic substance as the missing factor which the artificial miqueled sea-water must contain before it will sustain a vigorous growth of the diatoms. It has been noticed that artificial miqueled sea-water which has been kept for some weeks gives (without any addition of natural sea-water) more growth than does similar water used within a few days of being prepared. Plate-culture tests have shown that such water after a few days develops bacteria, and it is possible that the products of the metabolism of these bacteria are able to help the growth of the diatom.

The Omission of Miquel's Solutions. If 4 per cent of tank water (i.e. water from the Laboratory tanks, which are worked on a close system of circulation *) be added to artificial sea-water, made according to the formula already given, but to which neither of the Miquel solutions is added, a good growth will result after sterilization and inoculation with *Thalassiosira*. This growth may for the first week or two be quite as good as a similar culture to which the Miquel solutions have been added, but it will not continue healthy for as long as the latter, so that the total growth will be less. It is interesting to note that the mere dilution of the tank water with pure artificial sea-water produces an increase of growth, for the amount of growth obtained in say 100 c.c. of sterilized tank water is less than that obtained in a mixture of 96 c.c. of artificial sea-water with 4 c.c. of sterilized tank water. This is partly explained by a difference in alkalinity, but it also suggests that the tank water contains not only an abundance of the food substances which the diatoms require, but also substances which in higher concentrations are detrimental to growth, whereas in low concentrations their inhibitory action is reduced or disappears.

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* Cf. Allen and Nelson, *loc. cit.*, p. 430, *et seq.* [*Q.J.M.S.*, p. 373].

CHANGES IN THE COMPOSITION OF THE ARTIFICIAL SEA-WATER.

A series of experiments was made to ascertain to what extent the composition of the artificial sea-water could be changed without affecting the growth of *Thalassiosira*, and it was found that, provided 4 per cent of natural sea-water were added, the various constituents of the artificial water might be varied to a surprising extent without in any way retarding the growth. Only those results are included here which were quite marked and definite. Other variations in composition were tried, but an account of these is reserved until the experiments have been repeated and extended.

Varying the Amount of Magnesium Sulphate. A series of flasks was set up, the basis of the culture medium in each being artificial sea-water prepared according to the table on p. 424, the quantity of magnesium sulphate being varied. The full amount of alkali favourable to diatom growth was added (i.e. 2·6 c.c. of $M.NaHCO_3$ per litre), together with the usual quantities of 20 per cent KNO_3 and Miquel's solution B (Na_2HPO_4; $CaCl_2$; $FeCl_3$; HCl) and 4 per cent of natural sea-water. The series contained (*a*) no magnesium sulphate, (*b*) $\frac{1}{4}$ the normal amount, (*c*) $\frac{1}{2}$ the normal, (*d*) $\frac{3}{4}$ normal, (*e*) the normal amount, i.e. 29·06 c.c. of M.sol. per litre, (*f*) $1\frac{1}{4}$ times the normal and (*g*) $1\frac{1}{2}$ times the normal. All the flasks were inoculated in the same way with *Thalassiosira gravida*. During the first month all the flasks gave excellent growths, and it was not possible to distinguish between them. At the end of three months (*a*) and (*b*) had gone off more than the others, and (*f*) and (*g*) were not quite up to (*c*), (*d*) and (*e*). A repetition of (*a*) to (*e*) again gave the same result, the cultures being particularly large and healthy. In speaking of this result, it must be remembered that although the only sulphur present in (*a*) was that introduced in the 4 per cent of natural sea-water a considerable amount of magnesium was present as magnesium chloride.

Varying the Amount of Calcium Chloride. Another series of experiments was made in every respect similar to the last, excepting that the calcium chloride in the artificial water was varied instead of the magnesium sulphate, which remained normal: (*a*) contained no calcium chloride, (*b*) $\frac{1}{4}$ normal amount, (*c*) $\frac{1}{2}$ normal amount, (*d*) $\frac{3}{4}$ normal amount, (*e*) the normal amount, i.e. 10·86 c.c. M.sol. $CaCl_2$ per litre, (*f*) $1\frac{1}{4}$ times the normal amount, (*g*) $1\frac{1}{2}$ times normal.

(*a*) During the first week showed little sign of growth and was far behind the others. At the end of a month, however, there was quite a good growth, still very healthy, but the quantity was far below that in (*c*), (*d*), (*e*), (*f*) and (*g*).
(*b*) Small growth during the first week and remained always better than (*a*), but never equal to (*c*), (*d*), etc.
(*c*) Fair growth during first week and went on well, though the quantity was never up to (*d*), (*e*), etc.
(*d*) The growth was nearly equal to the normal (*e*) throughout, and at the end of a month it was not possible to distinguish between the two.
(*e*) A fine healthy growth with long chains.
(*f*) About the same as (*d*) throughout.
(*g*) About the same as (*d*) and (*f*) throughout.

A repetition of (*a*) to (*e*) gave just the same result. In connection with this series it must be noted that Miquel's B solution contains $CaCl_2$, so that the amount of Ca present in (*a*) will be that contained in the 4 per cent of natural sea-water, plus that contained in the Miquel B.

Varying the Amount of Potassium Chloride. An exactly similar series was set up in which the potassium chloride was varied from 0 to $1\frac{1}{2}$ times the normal. All these gave very fine growths, of which the last two ($1\frac{1}{4}$ and $1\frac{1}{2}$ times normal) were the best during the first week. Subsequently it was not possible to distinguish between the amounts in the different flasks. This result was also confirmed by a second experiment.

It should be remembered that potassium was added as nitrate in this as in the other experiments (2 c.c. of a 2 M.sol. KNO_3 per litre).

Variations in Salinity. It was shown in our previous paper * that in the case of *Skeletonema costatum*, *Biddulphia mobiliensis* and *Coscinodiscus excentricus*, plankton diatoms of very similar habit and distribution to the species *Thalassiosira gravida* chiefly used in the present experiments, the salinity of the culture medium could be varied within wide limits without greatly affecting the growth of the diatoms. Thus between 35 and 40 per cent of the water could be evaporated from a culture medium having natural sea-water as its basis without seriously affecting the growth of the diatoms, whilst dilution of the culture medium up to 100 per cent also made no appreciable difference. Even when the dilution was extended to 200 per cent a fair quantity of growth took place.

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* Allen and Nelson, *loc. cit.*, p. 453 [*Q.J.M.S.*, p. 402].

The following experiment was made in order to test the same point on *Thalassiosira gravida.*

Experiment 476. Artificial sea-water was made up with the normal relative proportions of salts, but of double the normal strength. A series of dilutions was then prepared, doubly distilled water being added in the proportions stated :

	Artificial sea-water, double strenth.		Doubly distilled water added.	
	c.c.		c.c.	
A ..	100	+	0	
B ..	100	+	25	
C ..	100	+	50	
D ..	100	+	75	
E ..	100	+	100	*Normal*
F ..	100	+	125	
G ..	100	+	150	
H ..	100	+	175	
J ..	100	+	200	

The right quantities of Miquel's solutions were added to each, and 4 per cent of sea-water from the Laboratory tanks. Flasks were then inoculated with three drops each of *Thalassiosira gravida* culture. No growth took place in A and B. Excellent, healthy growths with good chain formation took place in all the others. E and F were best, and one as good as the other. G and D were excellent growths, but the quantity at any time was less than in E and F. In C, H and J, although the growths were quite good the quantity was considerably less than in E and F, that in C also being less than in H and J.

It will thus be seen that very considerable changes in the salinity of the culture medium can be made without much effect being produced on the growth of *Thalassiosira.* Dilution of the medium is less detrimental than concentration.

The experiments described in this section show how wide the variation in the chemical composition of the culture medium may be without any very marked effect being produced on the growth of the diatoms. The difficulty in growing the diatoms in artificial sea-water is clearly not due, as at one time I thought might be the case, to the fact that a very delicate balance between the amounts of the different salts is necessary and that this balance had not been attained sufficiently exactly in preparing the solutions. It is quite clear that the artificial sea-water lacks some substance which occurs in natural sea-water, and that a very small trace of this substance is sufficient to make the difference between a considerable and continued growth of the diatoms and practically no growth at all.

GENERAL CONSIDERATIONS.

Several instances have recently been described which seem to show that in food material used to support animal life the presence of minute traces of particular organic substances is essential, if the food material is to maintain the animal body in a healthy state.

The work of Leonard Hill, M. Flack, G. Hopkins and Casimir Funk * has shown that in the outer layers of wheat and rice there is an active principle which is of essential importance to their value as food material. Young rats and mice would not live when fed exclusively upon white flour in the preparation of which the outer layers of the wheat had been removed, whilst those fed on whole meal flour did much better. Pigeons could be successfully fed on bread made of white flour to which an extract of bran and sharps had been added, but when fed on pure white bread all died. Polished rice from which the husk has been removed in the process of polishing, when used as an exclusive diet, produces the disease known as beri-beri. Cooper and Casimir Funk † were able to isolate from rice polishings a substance to which they gave the name vitamine, which effected a rapid cure when given to pigeons suffering from beri-beri. The same substance was obtained from yeast, from milk and from bran.

Hopkins ‡ has shown that young rats do not grow on an artificial diet composed of pure protein, starch, cane sugar, lard and inorganic salts, but if quite a small quantity of natural milk is added to the diet they thrive.

Thornton and Geoffrey Smith § have shown that strong growths of *Euglena viridis* in culture media prepared according to Miquel's formula are produced when in place of the organic matter used by Miquel slight traces of amido acids are added to the solutions of inorganic salts. Tyrosin in the proportion of 1 in 24,000 gave an optimal growth. The authors suggest that the amido acid acts as an auxiliary or stimulant rather than as the main source of nutrition. This view is similar to that taken by H. C. Ross in his work on *Induced Cell-Reproduction and Cancer*, to which reference has already been made (see p. 432).

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* A summary of this work, as described at the meeting of the British Association in Dundee (1912), will be found in *Science Progress*, January, 1913, pp. 423–5.

† *The Lancet*, Nov. 4th, 1911, p. 1266.

‡ *Journal of Physiology*, Vol. XLIV, 1912, p. 425.

§ *Proceed. Roy. Soc.*, B., Vol. LXXXVIII, p. 151, 1914.

It would seem that the plankton diatoms, the culture of which has been considered in the present paper, show a phenomenon of a similar character to those just mentioned. The minute trace of substance added to the culture medium in the small percentage of natural sea-water would seem to act as a catalytic agent, initiating the processes of metabolism but not being itself used up.

The experiments may also help to throw light upon what takes place in the sea. It is well known that the waters of the open ocean far from land support a much smaller proportion of plant and animal life than is to be found in coastal waters. On the other hand, in regions where a current of coastal water meets and becomes mixed with a current of ocean water conditions are produced which are specially favourable to a luxuriant growth of animal and vegetable life. This is shown in the first place in the very rich character of the plankton, and as a consequence of the abundant plankton we find a rich fauna of bottom living organisms and of fishes of different kinds. This is in agreement with the observation recorded in the present paper that a small quantity of natural sea-water of an inshore type (tank-water) mixed with a large proportion of pure artificial sea-water gives a good culture medium for the plankton diatoms. There is reason to hope therefore that culture experiments may in time throw additional light upon the general questions relating to the production of animal life in the sea, questions which are of immediate importance to a study of the productivity of the fisheries.

SUMMARY.

1. Attempts to obtain good cultures of *Thalassiosira gravida* in a purely artificial medium, made by dissolving in doubly distilled water Kahlbaum's pure chemicals in the proportions in which the salts occur in sea-water, adding nitrates, phosphates and iron according to Miquel's method and sterilizing the medium, have not succeeded.
2. If, however, a small percentage of natural sea-water (less than 1 per cent will produce a result) be added to the artificial medium and the whole sterilized excellent cultures are obtained, which are often better than any which have been got when natural sea-water forms the foundation of the culture medium.

3. The result appears to be due to some specific substance present in minute quantity in the natural sea-water which is essential to the vigorous growth of the diatoms. The nature of this substance it has not been possible to determine, but some evidence seems to suggest that it is a somewhat stable organic compound.
4. Provided the 1 per cent of natural sea-water is added, the various constituents of the artificial sea-water forming the basis of the culture medium can be varied in amount within wide limits. The salinity of the medium can also be considerably altered without serious detriment to the cultures.
5. The experiments recorded are of interest as furnishing another instance of the importance in food substances of minute traces of particular chemical compounds. They may also eventually throw light upon the nature of the conditions in the sea which are specially favourable to the production of plant life and therefore also of the animal life which that plant life sustains.

ADDENDUM.

Since the above was printed a paper has been published by Prof. W. B. Bottomley on " Some Accessory Factors in Plant Growth and Nutrition " (*Proceed. Roy. Soc.*, B., Vol. LXXXVIII, p. 237, Sept., 1914), in which it is shown that a minute trace of an organic substance, which is formed by the action of aërobic soil bacteria upon peat, acts as a powerful stimulant to the growth of plants and of nitrogen-fixing bacteria. Following the method of Cooper and Funk for obtaining " vitamines " from rice polishings, namely, by precipitating by phosphotungstic acid from an aqueous solution of the dry residue from an alcoholic extract, Bottomley has succeeded in obtaining from the bacterized peat a substance which is quite as powerful a stimulant to plant growth as the original alcoholic extract of the bacterized peat. This substance, as in the case of Funk's vitamines, can be further purified by precipitation with silver nitrate and baryta, the resulting substance being an effective growth stimulant.

A Study of the Restitution Masses formed by the Dissociated Cells of the Hydroids *Antennularia ramosa* and *A. antennina*.

By

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From the Laboratory of the Marine Biological Association at Plymouth.

Figures 1–9 in the Text.

TABLE OF CONTENTS.

	PAGE
Introduction	440
Methods and Technique	443
The normal tissues which, after dissociation, give rise to the restitution masses	445
The process of formation of restitution masses	448
The morphology and duration of life of the restitution masses	451
The histology of the restitution masses	453
Synopsis of experiments	458
Summary and conclusion	462

INTRODUCTION.

The work described in this paper is, in the main, a repetition of that of H. V. Wilson, "On the Behaviour of the Dissociated Cells in Hydroids, Alcyonaria, and Asterias," published in October, 1911, in the *Journal of Experimental Zoology*. The results he obtained are so far-reaching in their bearing on the present theories of the organization of living matter that his work appeared well worth repeating on species closely allied to those on which he experimented. Our results largely bear out his contentions, though we were not successful in carrying the regenerative process as far as the production of new hydranths, and the histological structure of the restitution masses we obtained differed in many ways from that described in Wilson's paper. These differences are probably due to the fact that we experimented with other species of Hydroids to those used by Wilson: in other respects we have followed his technique and repeated his experiments, and up to a certain point have obtained the same results, and thus it may be considered that we have verified his very remarkable work.

The especial interest of our investigations lies in the rather anomalous fact that we have not been successful in obtaining regeneration of the complete organism from the dissociated cells. In our experiments the restitution masses, by some rearrangement or metaplastic process taking place among their conglomerated cells, formed tissue aggregates histologically reduplicating the structure of the parent organism, but in a quite irregular and apparently meaningless manner. The masses consisted of irregular convoluted tubules lined with endoderm cells, imbedded in closely packed but irregularly arranged ectoderm cells, among which many isolated endoderm cells were distinguishable, and the whole tissue aggregate was surrounded by a transparent perisarc which it had secreted. Slight contractions and alteration in shape in the cell masses often took place even after several weeks, and many of them remained alive and showed no signs of degeneration for at least fifty days, which was very much longer than the Hydroids themselves could be kept alive under similar conditions.

Before proceeding further it will be as well to briefly summarize the results obtained by H. V. Wilson. The Hydroids on which he experimented were *Eudendrium carneum* Clarke, and *Pennaria tiarella* McCrady. Proceeding as described in his paper, he squeezed pieces of the Hydroids through bolting silk of 50 and 75 meshes to the inch and then allowed the dissociated cells to form aggregate masses. The following is an abstract of some of his experiments.

Eudendrium carneum.

Experiment, July 9. A colony was squeezed, and fusion was observed under the microscope. In a few hours irregular, lobed, flattened masses about 5 mm. wide and 1 mm. thick were formed. By the next day, a perisarc surrounding the whole mass had been secreted. In 4 days outgrowths had formed in which ectoderm and endoderm could be distinguished. Some of the masses died, but others remained alive. These were isolated, and in 24 hours, one projecting outgrowth ended in a hydranth, and a day later two completely formed hydranths were developed from another mass. These hydranths have the characteristic size, shape, and colour of the normal adult polyp.

Experiment, July 14. The tissue died before mass formation.

Experiment, July 15. Flattened plasmodial masses and lumps were formed, but soon died.

Experiment, July 18. Tissue died.

Experiment, July 19. Tissue formed, but died next day.

Experiment, July 22. Tissue died next day.

Experiment, July 23. Tissue died next day.

Experiment, July 25. Small masses of tissues were formed, and secreted perisarc. They were alive 4 days after formation.

Experiment, July 27. Most of the large pieces of tissue died, but small lumps were alive 4 days later, and cœnosarcal outgrowths had sprouted.

Experiment, August 1. Small masses a fraction of a millimetre lived, showed perisarc and were alive 2 days later.

Experiment, August 2. (*a*) Most of the tissue formed was alive on August 3rd; much died by 7th. Outgrowths were formed, with vertical branches by 11th, but were sickly.

Experiment, August 2. (*b*) Many small spheroidal masses formed, and developed perisarc, but not cœnosarcal outgrowths. They were alive 5 days later.

Pennaria tiarella.

Experiment, July 26. Cell fusion and aggregation commenced at once. Small masses formed in an hour, and fused into tissue. In about 4 hours masses 1 mm. in diameter have formed. Next day perisarc formed, and in 3 days outgrowths were developed, but at the same time many of the larger masses died. In 5 days hydranths appeared on the outgrowths with characteristic tentacles.

Experiment, August 3. In this experiment only stem material was used. Fusion was rapid, and in about an hour a cake was formed. Next day perisarc appeared, and outgrowths commenced. Another mass from this culture in two days developed a hydranth. In 5 days all masses of this experiment except 4 were dead; the survivors developed outgrowths and were then preserved.

Many other valuable observations are included in Wilson's paper, but these experiments are the only ones with which we are immediately concerned. The paper also contains a full account of the literature on the subject of the behaviour and the regenerative properties of dissociated somatic cells of various species of animals, and accordingly a review of this literature will not be repeated here.

It is noteworthy that in Wilson's experiments the restitution masses which did not develop so far as to produce hydranths in every case died within a few days, while in our experiments, though none of the restitution masses produced hydranths, yet many of them remained alive for at least 60 days. Wilson does not state how long the masses which gave rise to hydranths in his experiments remained alive.

METHODS AND TECHNIQUE.

The species used by Wilson at Beaufort N.C., U.S.A., were not available at Plymouth. The species on which most of our experiments were carried out were *Antennularia ramosa* and *Antennularia antennina*. Species of Tubularia, Plumularia, and Clava were also tried, but did not give satisfactory results; though many of these produced restitution masses from their dissociated cells, yet these masses did not remain alive for more than a few days, and accordingly *Antennularia ramosa* or *A. antennina* were used in all our later experiments.

All material was obtained from Plymouth Sound, inside the Breakwater.

The method of obtaining the isolated cells was the same as that employed by Wilson. Squares of bolting silk of 50, 75, and 180 meshes to the inch were thoroughly washed and finally rinsed out in boiling water. A good sized colony of Antennularia was then cut up into small pieces about a quarter of an inch long and these pieces were laid in a heap in the middle of a square of bolting silk, which was then folded over so as to make a small bag containing the fragments of the Hydroid. This bag was then squeezed with a pair of wooden forceps into a watch-glass containing a little sea-water. With a quite moderate degree of pressure the body cells of the Hydroid are forced out of the cut ends of their protecting tubes of perisarc and then through the meshes of the bolting silk, and by this process become separated into isolated cells or small cell aggregates which collect as an even layer at the bottom of the watch-glass. It is necessary that a sufficient amount of material should be used to form a complete layer of isolated cells at the bottom of the watch-glass about 1 mm. thick, if the formation of restitution masses that will show any degree of subsequent development is required.

The watch-glasses containing the isolated cells were slightly shaken and rotated so as to bring the cells together as much as possible, and then when they had aggregated to some little degree the watch-glass was immersed in a finger-bowl of sea-water. It was found advisable to place the finger-bowls in troughs of running water in order to keep them cool and at a more or less constant temperature ; before this was done a very large mortality among the restitution masses occurred even under the most favourable conditions, and it would seem that the temperature of the laboratory, which is heated by hot water, was too high for these unless some artificial method of cooling was employed.

Two kinds of water were used in the experiments : (1) that brought from outside the Plymouth Breakwater, and (2) water circulating in the Laboratory tanks, treated with animal charcoal and passed through a Berkefeld filter as described by Allen and Nelson (see *Journal of Marine Biological Association*, Vol. VIII, p. 432). It proved, however, immaterial which kind of water was used. For the first day or two the water of the cultures was changed frequently with a view to keep down the infusoria and flagellates as much as possible ; but it is impossible to banish them altogether, and as soon as a perisarc was well established round the masses they were immune to attacks of protozoa. After this time the culture water was not changed oftener than once a week. Possibly the flagellates developed more quickly in the Berkefeld than in the outside water.

It was found advisable to utilize the colonies of Antennularia immediately after they were brought in, as by this means more vigorous restitution masses were obtained. If the colonies were kept over night in the ordinary tank water, in the filtered Berkefeld water, in water collected from outside the Breakwater, satisfactory results were not obtained. In one experiment, however, excellent results were obtained from a colony of *A. antennina*, which had lain for some weeks in a laboratory tank. The comparative greater longevity and vitality under Laboratory conditions of the restitution masses compared to the original colonies is very curious and difficult to explain.

The changes in shape and other general external developments of the restitution masses were noted by frequently drawing under a camera lucida : for this purpose the watch-glasses containing the cultures were simply removed from the finger-bowls and placed on the stage of the microscope ; after drawing they were returned to the finger-bowls without disturbing the cultures.

When required for histological examination, the restitution masses were fixed in Flemming's fluid (strong formula). Ten minutes fixation was found to be long enough for a moderate sized mass, say about the size of a grain of barley ; if fixed for longer periods the cells showed a tendency to become "osmicated" and stained badly. After fixing they were washed for a few minutes in water, passed quickly up through the alcohols to 70%, and then washed for some hours in 70% alcohol, containing a little hydrogen peroxide. After dehydration they were embedded in paraffin and cut into sections 5μ thick. Heidenheim's Iron Alum Hæmatoxylin, followed by Lichtgrün F.S. in 70% alcohol proved a satisfactory stain for general purposes.

Small restitution masses which were difficult to handle were sectionized after previously mounting on a piece of amyloid liver, the mass being made to adhere to the surface of the liver by means of a little albumen, which was subsequently coagulated by alcohol.

THE NORMAL TISSUES WHICH, AFTER DISSOCIATION, GIVE RISE TO THE RESTITUTION MASSES.

Antennularia ramosa is one of the Plumulariidæ. It consists of shoots which, springing from a single trunk at a certain height, divide and subdivide : the stems are thick and their branchlets are long and tapering, having their internodes of equal length. The branchlets are closely set and arranged in whorls where they come off the parent stem. The Hydrothecæ are small and campanulate in shape. Nematocysts are present. The Gonothecæ are pear-shaped and single ; and have a subterminal aperture facing towards the stem. In healthy specimens the perisarc is transparent and colourless, and the coenosarc is of a light yellowish green tinge.

Antennularia antennina consists of clustered stems, simple or slightly branched, springing from a sponge-like mass of interlacing fibres. The branchlets are short, swollen at the base, arranged in a whorl on each articulation of the stem. They are divided by oblique joints into internodes, which are alternately larger and smaller, the former bearing the hydrothecæ. The hydrothecæ are small and campanulate in shape. The Gonothecæ are produced singly in the axils of the branchlets ; they are oval, with a subterminal aperture looking towards the main stem. The perisarc is transparent and colourless, and the cœnosarc of a somewhat brighter yellow colour than in the case of *Antennularia ramosa*.

The cœnosarc of both species is hollow, and consists of a tube of cellular tissue in the walls of which a number of smaller tubes run in the direction of the long axis of the stem. These smaller tubes are the direct continuations of the enteric cavities of the individual hydranths, and are lined with cells of a type similar to those forming the hydranths. The whole arrangement is suggestive of that in a young dicotyledonous plant having a hollow stem, the enteric cavities lined with the endoderm cells of the individual hydranths corresponding to the vascular bundles of the plant.

A view of a cross section through a stem of *Antennularia ramosa* is shown in Fig. 1. Externally it is limited by the structureless perisarc, within this is a somewhat indefinitely arranged mass of slightly elongated cells with small but sharply staining nuclei; of these the cells in immediate contact with the perisarc are larger than the others, which appear to be tightly packed together. At regular intervals within this

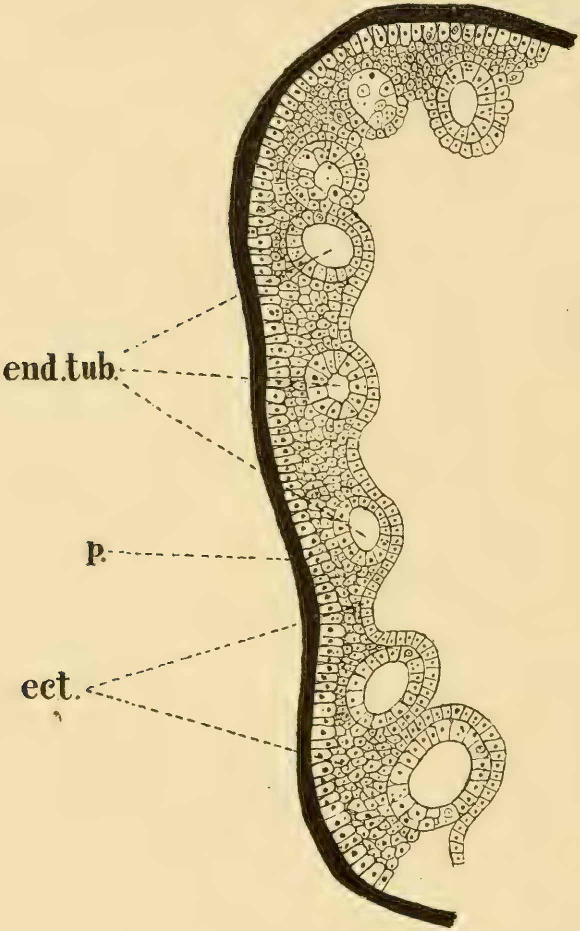

Fig. 1. ×175.—Section of portion of normal cœnosarc, showing cœnosarcal continuations of tubules continous with the enteron of individual polyps. *End. tub.*, endoderm tubules; *p.*, perisarc; *ect.*, ectoderm cells.

cell mass tubules lined with large columnar endoderm cells can be seen, and these tubules are covered on the side where they project somewhat into the hollow cavity of the stem with a single layer of small cubical cells, which form a complete inner lining to the hollow stem. In longitudinal sections the tubules can be traced up into the individual polyps, and it can readily be seen that their cells are directly continuous with the endoderm cells lining the enteric cavity of the polyps. Similarly the smaller cells in which these tubules are embedded in the cœnosarc can be seen to be directly continuous with the ectoderm cells of the polyps. Neither in sections of the cœnosarc nor of the polyps were we able to distinguish any structure or structureless layer corresponding to the mesoglæa.

In Fig. 2 a tubule with surrounding ectoderm cells is shown under a higher power of magnification. It will be noticed that the endoderm cells are distinctly columnar, with broad bases, and that they are considerably larger than the ectoderm cells. Their nuclei are relatively large, and usually situated near the base of the cell: the nuclear membrane is sharp and well defined and the nucleoli are remarkably distinct; strands of chromatin are present, radiating from the nucleolus towards the nuclear membrane. The cytoplasm is distinctly granular, and frequently darkly staining vacuoles, presumably food vacuoles, were seen. Flagella do not appear to be present on these cœnosarcal endoderm cells.

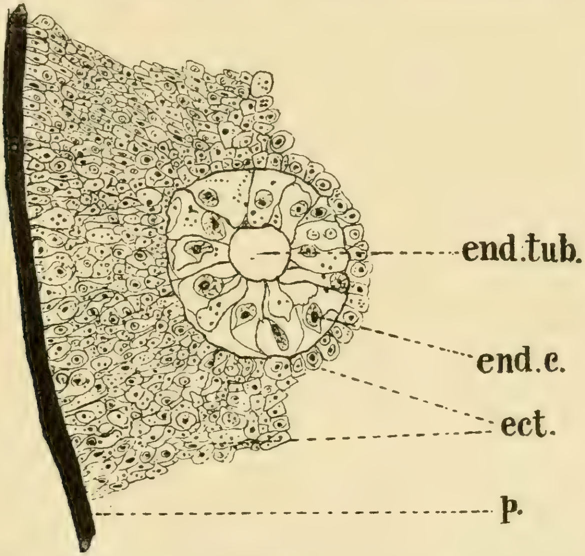

Fig. 2. × 500.—A normal tubule under higher power of magnification. *Ect.*, ectoderm cells; *end. c.*, endoderm cells; *end. tub.*, endoderm tubules; *p.*, perisarc.

The smaller ectoderm cells are slightly elongated, often with pointed ends, with the exception of those forming the layer lining the hollow of the cœnosarc, which are almost cubical in shape. The nuclei are small, and the nucleoli relatively large and distinct.

Other structures such as the germ cells, nematocysts, etc., are not described here as they appear to merely play the part of foreign bodies in the restitution masses, and do not enter into their development.

THE PROCESS OF FORMATION OF RESTITUTION MASSES.

The cells that are obtained after squeezing through bolting silk of 50 meshes to the inch are, many of them, comparatively little damaged; but if a finer silk is employed, such as that having 180 meshes to the inch, the majority of the cells are crushed and broken. It would appear that the injury caused by squeezing through a fine meshed silk is due rather to the relatively greater pressure that must be applied to the bag containing the pieces of Hydroids in order to drive the cells through the fine meshes than to the actual size of the meshes themselves. Restitution masses that would live more than a few days, and which would show any degree of subsequent development, were not obtained when a finer mesh than 50 to the inch was employed, and accordingly this was most generally employed.

An examination of the cells immediately after squeezing through a 50-mesh silk showed that the majority of them were single and isolated from their neighbours; small cell aggregates consisting at the most of six or eight ectodermal cells were present, and aggregates consisting of a smaller number of endodermal cells could be seen. These endodermal-cell aggregates, as well as the isolated endodermal cells, were in active motion caused by the action of their flagella: in the case of the isolated cells this motion consisted in progression in a number of small spirals due to the fact that the flagella are only attached to one side of the cell.

In addition to the comparatively uninjured cells and cell aggregates, a good deal of granular debris was present, and minute rounded bodies which were presumably small protoplasmic masses produced by the disintegration of cells which had been actually crushed in the squeezing process. Many nematocysts, some with their threads ejected, could also be seen, and ova were often present. In some cases small pieces of the tentacles accidentally were forced through the meshes of the silk intact; but these were usually visible to the naked eye, or under a low power of magnification, and when seen were removed with fine-pointed forceps.

If such pieces of tentacle were not removed, and became included in the restitution masses, it was noticed that they soon degenerate and never show any sign of regeneration, and in this our observations agree with Wilson's.

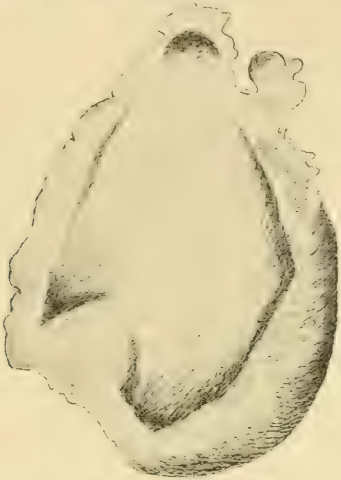

FIG. 3. ×16.—A restitution mass 48 hours old, showing curling up of edges.

Preparations of the freshly squeezed cells were made by fixing on a slide with Acetic Sublimate Solution, and subsequent staining with Heidenheim's Iron Hæmatoxylin, followed by Lichtgrün F.S. (Fig. 4). In such preparations both the ectodermal and endodermal cells were easily recognizable, though the proportion of endodermal cells was

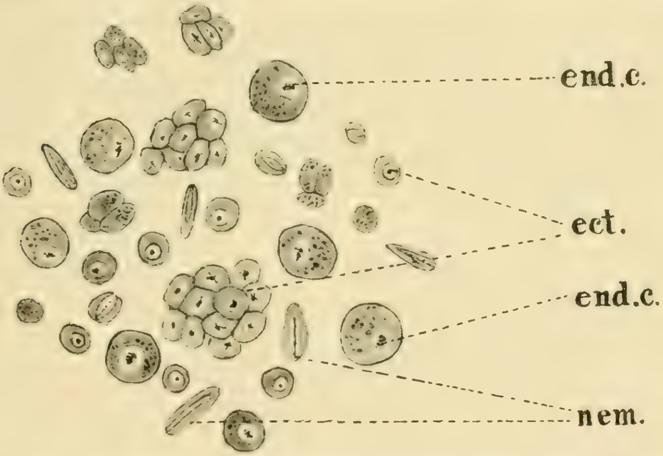
end.c.
ect.
end.c.
nem.

FIG. 4. ×500.—Isolated cells, after squeezing through bolting silk of 50 mesh. *Ect.*, ectoderm cells ; *end. c.*, endoderm cells ; *nem.*, nematocyst.

comparatively small compared to the number seen in unfixed preparations. This was probably due to the fact that the endodermal cells, being kept in motion by their flagella, do not settle down on the surface of the glass like the nonmotile ectoderm cells, and consequently do not adhere to it on the addition of the fixative.

Examination of these preparations (Fig. 4) showed that the ectodermal cells had mostly become rounded, their nuclei were somewhat indistinct, and no nuclear membrane was distinguishable. The nucleoli in some cases stained darkly, and from them a few short radiating strands of chromatin could often be made out, but in other cases the whole nuclear structure stained faintly and appeared as a roughly spherical mass of indeterminate structure. The cytoplasm of these cells was clear, the periphery often staining somewhat darker than the more central part. Where occurring in small aggregates, the ectodermal cells appeared comparatively uninjured, and closely resembled the normal. In the case of the isolated cells it would seem as though the pressure to which they had been exposed had burst the nuclear membrane and caused a fusion of the nucleoplasm and cytoplasm.

The larger endodermal cells in these fixed preparations had lost their columnar shape and become rounded, and their flagella were not seen. The nuclei were indistinct and appeared as a light area in which a few granules of chromatin could be distinguished, surrounded by the darker cytoplasm. In most of the cells the cytoplasm had lost its granular and vacuolated character, but in a few some darkly staining granules were present. As might be expected from their larger size, the endoderm cells appear to have suffered more from the squeezing process than the smaller endoderm cells.

Interspersed between the cells all over the preparations were large numbers of nematocysts, many of them apparently uninjured, and granules and globules derived from disintegrated cells and the contents of the enteric cavities of the Hydroids.

After squeezing through bolting silk into a watch-glass containing a little water, the isolated cells, small cell aggregates, and general debris, which escape through the silk, soon settle down and form an even layer of a greyish yellow colour over the bottom of the watch-glass. Within two or three hours this layer shows a tendency to subdivide into a number of small nodules, and after the lapse of another hour these nodules are usually distinct elevated aggregations, often connected with one another by fine strands which gradually become thinner and contract until they are absorbed into the nodules from which they radiated. If left undisturbed, there seems to be no tendency for these nodules to change their position, but if they are disturbed by shaking or rotating the watch-glass so that they are brought into contact with one another they mutually adhere, and in the course of some hours may give rise to one or more large restitution masses in which no trace of the smaller nodules originally formed can be distinguished.

Similarly if the watch-glass, immediately after the cells have been squeezed into it, be rotated so that all the cells form a compact heap in the centre, the restitution masses may be formed as one or more thick flat cakes with rounded edges without the preliminary formation of the smaller nodules described above.

THE MORPHOLOGY AND DURATION OF LIFE OF THE RESTITUTION MASSES.

The after history of a restitution mass depends very much on its original size when first formed, and this again depends on whether the dissociated cells were shaken together or allowed to form the small nodular masses already described.

When one of these larger masses of tissue is first formed it consists of a flat cake of tissue of irregular shape, sometimes adherent to the glass. During the first 12 hours after its formation, a considerable amount of alteration in shape occurs, the edges of the mass turn up away from the glass, and a good deal of retraction takes place and consequently the tissue becomes stronger and more compact. After from 12 to 18 hours a delicate, transparent, colourless membrane is secreted round the mass, completely enclosing it and forming a tough protecting layer: this layer

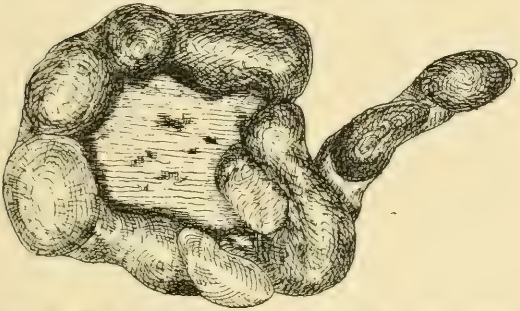

FIG. 5. × 16.—A restitution mass 8 days old, showing curling up and nodulation of edges.

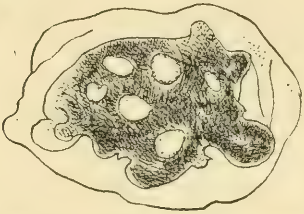

FIG. 6. × 16.—A restitution mass 34 days old, showing well-marked shrinkage away from the perisarc and fenestrated appearance of the cell mass.

is evidently similar to the perisarc of the normal animal. Once this perisarc has been secreted, the restitution mass appears to be immune to the attacks of flagellates or bacteria, which are unable to penetrate it. From this stage onwards the external changes that occur take place slowly. The turned-up edges become thicker and more nodulated at the expense of the central part, and sometimes may project in the form of spherical or ovoid nodules connected at the base with the main mass by a comparatively small isthmus of tissue. (In Fig. 3 a mass, 48 hours old, is shown, and in Fig. 5 one of 8 days.) There is later a slow but continuous shrinkage of the restitution mass away from its perisarc, leaving a clear space between the two (Fig. 6), after from three to four weeks irregularly circular spaces begin to show in the cell mass, which then presents a somewhat sponge-like fenestrated appearance (Fig. 6). Later changes are extremely slow, and consist of a further slight shrinkage, and increase in size of the spaces in the tissue. During all this time the restitution mass retains its yellowish colour and definite outlines, and sections show that the cells are healthy and undegenerated : in the case of masses that die, the yellowish colour is rapidly lost, and they appear as dirty white, soft, floccular bodies, which soon fall a prey to bacteria and other parasites ; it is thus easy to distinguish the living from the dead masses by the eye.

At the time of writing some of these masses have been kept alive for a period of 60 days, and during this time none of them have shown any tendency to regenerate a stem or hydranth.

In the case of the smaller nodular masses that had not been shaken together so as to form larger aggregates, a perisarc was secreted in from 12 to 18 hours, and where several nodules were joined by their strands of tissue a complete tube of perisarc was secreted around these connecting strands. The appearance presented in such cases was often peculiar and somewhat suggested an attempt at the formation of hydranths which had aborted through not being able to burst the surrounding perisarc ; but observations made from the earliest stages, when the nodules arose from simple aggregations of the cells show that there is no justification for such a view, and this was borne out by the internal structure of these nodules as shown in sections of fixed preparations. When the process of contraction of the restitution masses had proceeded a little further, the connecting strands of tissue between individual nodules were often completely retracted, thus leaving the nodules merely connected by empty tubes of transparent perisarc.

THE HISTOLOGY OF THE RESTITUTION MASSES.

Our observations on the histology of the young restitution masses agree closely with those of Wilson, so that it is not necessary for us to describe the younger stages in great detail.

A section of a young restitution mass from 18 to 24 hours old shows that a perisarc has been secreted, and that it is still in close contact with the cell mass. The central cells are irregular, and show no trace of stratification : the ectoderm and endoderm cells can be recognized, and present a similar appearance to that described as seen in preparations of the freshly squeezed cells, with the exception that the endoderm elements were even less definite, contained no granules and were distinguishable in relatively small numbers : a few of the cells retained their definite outlines, but others were less distinct and appeared to join up with their neighbours by means of pseudopodia-like processes. It would seem probable, as Wilson suggests, that the structure throughout is that of a cellular syncytium, and that even where the cells appear distinct they are united by protoplasmic strands. He also remarks that the endoderm cells form only a small fraction of the syncytium, though they composed a very large part of the mass when fusion began. This he explains by considering that the endoderm cells undergo a transformation which effectually precludes their recognition later, and we would suggest that the majority of these cells take on a plasmodial character, and so by forming a protoplasmic reticulum unite and draw together the other elements of the mass.

The peripheral cells in contact with the perisarc in these young restitution masses take on an epithelial character quite early, as might be expected from the fact that they have secreted the perisarc. They are distinguishable as a layer of cells resembling those forming the normal ectoderm, with flattened bases in even contact with the perisarc, and they are recognizable several days before any other rearrangement of the cells is apparent in the mass.

A comparison between sections of early and later stages shows that the nematocysts included in the masses gradually disappear and take no part in the further development. A similar observation has been made by Wilson.

Sections after 6 days (Fig. 7) show that the cells are much more definite, the individual cell walls show clearly and the nuclei of the ectoderm cells stain distinctly ; the mass has largely lost its plasmodial indefinite character, much of the cell debris has disappeared and the nematocysts are not present or are not recognizable, and have probably been dissolved away. Some irregular darkly staining masses suggestive of endodermal cells are present, but they are somewhat indefinite. The more distinct ectoderm cells are often arranged in whorls or rows, and the external layer which secreted the perisarc is well defined. The impression conveyed by examination of sections at this stage is that some process of rearrangement has been initiated among the cells, but there is little to show what may be expected to be the result of this rearrangement. No mitoses were observed.

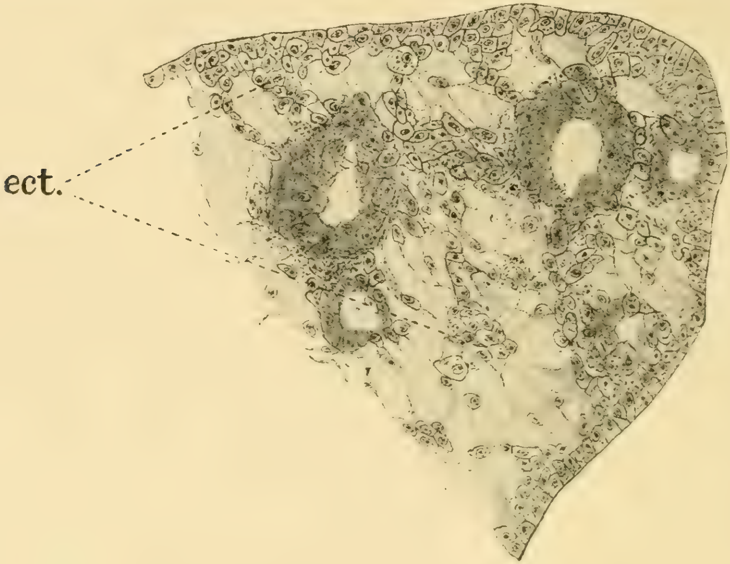

Fig. 7. × 260.—Section through part of a restitution mass 6 days old, showing indefinite arrangement of cells. The ectodermal cells are fairly well differentiated; but the endodermal elements, though showing a tendency towards tubule formation, are not well defined. The perisarc is not shown. *Ect.*, ectoderm cells.

Seven days later development has proceeded much further, many cells definitely of the endodermal type are present, and they contain numbers of small granules in their cytoplasm. These cells are often arranged so as to form distinct tubules, each having a definite lumen and closely resembling in structure the cœnosarcal part of the enteron of an individual polyp. In other places the endodermal cells are arranged in rows, in irregular masses, or singly, embedded among the ectodermal cells. Where formed, the tubules are always in any one section cut transversely, longitudinally, and at intermediate angles, hence they must be irregularly coiled and crossed within the mass. At this stage the ectodermal cells are sharp and distinct, approximating the normal in size but slightly larger; they have a tendency to be fusiform in shape with sharply pointed extremities, and are often joined end to end. Spaces between the cells are frequent, but they are occasionally found arranged in compact whorls or masses. The outline of the cells is well defined, the cytoplasm clear but slightly vacuolated, the nuclear membrane and nucleolus distinct.

Sections of restitution masses at the end of 3 weeks (Fig. 8) showed a still more definite arrangement of convoluted endodermal tubules. The cells forming these tubules were regularly arranged and closely resembled those lining the enteric cavity of the normal polyp with the exception that no flagella were seen. The cytoplasm of these cells was crowded with large granules, which were often so plentiful as to partially obscure the nucleus. The ectoderm cells were present in even smaller numbers than in earlier stages, but were very definite in structure. Occasional large spaces, corresponding to the spaces producing the fenestrated appearance described as occurring in older masses, were seen among the cells, and other areas in which the cells had degenerated and left merely some granular debris were observed.

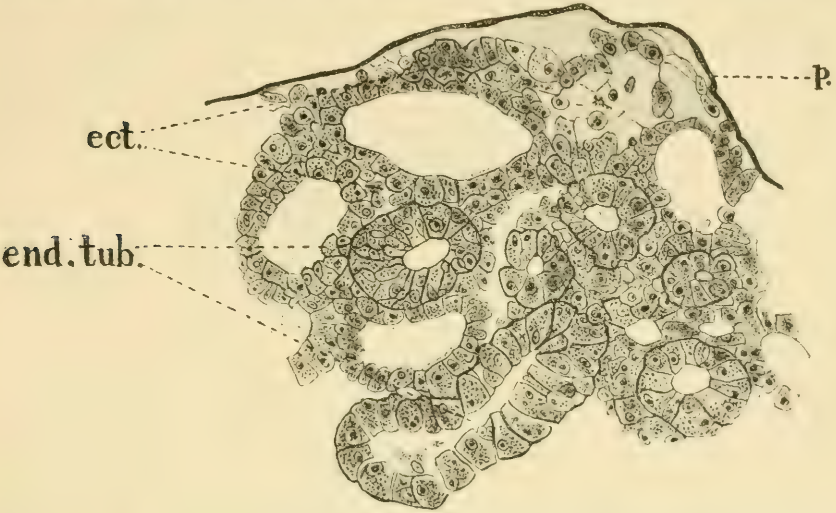

FIG. 8. ×260.—Section through part of a restitution mass 20 days old, showing formation of definite endodermal tubules; all the cells in the mass are sharp and well defined, and the plasmodial character noticeable in earlier stages is lost. *Ect.*, ectoderm cells; *end. tub.*, endoderm tubules; *p.*, perisarc.

At the end of 5 weeks (Fig. 9) the endodermal cells forming the tubules had become crowded with darkly staining spherical granules of varying size, often totally obscuring the nucleus, and the ectoderm cells often partially or completely surrounded the tubules in the form of a well-defined single cell layer. In some cases the cells of the tubules had apparently undergone autolysis, and a space containing a little granular cell debris was left surrounded by the ectodermal layer.

Later the stages show little change or further degeneration. Sections after 50 days show that a large proportion of the endodermal cells are crowded with granules, and many of the tubules have disappeared; on the other hand, the ectoderm cells are quite undegenerated. At the time of writing such restitution masses have been kept alive and in apparent health for 60 days.

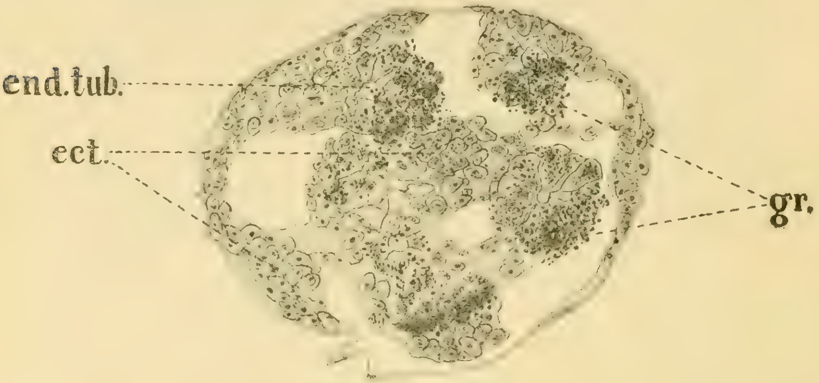

Fig. 9. ×260.—Section through a small restitution mass 35 days old, showing the formation of many granules in the endoderm cells. Some of these cells are breaking down, so that the tubules are less distinct. The ectoderm cells remain healthy. *Ect.*, ectoderm cells; *end. tub.*, endoderm tubules; *gr.*, cytoplasmic granules.

No signs of mitosis or any form of cell division was observed in any stage.

We would suggest that the changes that take place may be explained as follows:—

The endoderm cells are considerably more damaged in the process of squeezing through the bolting silk than the smaller and tougher ectoderm cells. They lose the majority of their cytoplasmic granules, which are probably in the nature of a digestive ferment, and the nuclear membrane is usually ruptured, causing certain changes in the nuclear structure. As the cells begin to form aggregates the endoderm cells become diffuse and join with each other by means of protoplasmic processes to form a plasmodium, in the midst of which the comparatively uninjured ectoderm cells are embedded. Certain ectoderm cells make their way towards the periphery of the mass, or are left there by the contraction of the plasmodium away from them, and secrete a perisarc within 12 or 18 hours. This resumption of function in so short a time and the localization of the secreting power so that secretion of perisarc takes place only on the outside of the mass, is somewhat remarkable, considering that all the normal relationships between the cells must have been completely upset. Contraction of the plasmodium of endoderm cells still continues, eventually causing the mass to contract away from the perisarc, and it is noteworthy that when this occurs no fresh perisarc is secreted by the peripheral cells. If, however, a small piece of the perisarc is removed, it is rapidly re-secreted by the cells in the neighbourhood, and the gap is healed. From this it would seem possible that the secretion of perisarc is a direct reaction of the ectoderm cells when in contact with sea-water, and that it is not produced when they are in contact with the fluid filling the space between the shrunken mass and the perisarc, and that accordingly this fluid has a different constitution to sea-water.

During the retraction of the plasmodium, the endodermal cells gather together their ramifying processes and again become differentiated, and so very slowly resume their normal form. Of the manner in which many of them become collected so as to form definite tubules, we are unable to offer any explanation. The appearance of sections at a period when the earliest stages of tubule formation are apparent suggests that the plasmodial masses, which will later develop into endodermal tubules, become arranged and segregated before they have differentiated into recognizable endoderm cells, but this is the merest surmise. In cases like this, where individual cells cannot be watched through their modifications and development, the value of the evidence of sections of different masses is always doubtful. Considering that no sign of cell division was ever seen in our experiments it would seem strongly probable that a certain amount of actual migration and rearrangement of the cells within the masses must occur, but no clue is given as to the form or mode of action of the forces causing this rearrangement. As in the case of Wilson's experiments, however, it is difficult to imagine any "form regulation" force coming into play after isolation and subsequent agglomeration of the individual cells forming the original organism.

We consider that the granules found in the cytoplasm of the endodermal cells in the older restitution masses are probably in the nature of the proenzyme of the digestive ferment. Since the tubules are closed, and there is no food stimulus, the granules are not discharged, but accumulate in the cell up to a certain limit: when this is reached the cell ruptures and autolysis ensues. From the fact that these granules are formed, it follows that a certain amount of active metabolism is going on within the mass, and from the disappearance of the cell debris, nematocysts, ova, etc., which are included in the restitution masses when first formed, it would seem at least possible that these may be absorbed and used up in the metabolic processes of the living cells. Similarly the living cells may feed on those which degenerate.

SYNOPSIS OF EXPERIMENTS.

Numbers omitted belong to experiments not dealt with in this paper.

Experiment 1.—A colony of *Antennularia antennina* dredged on 5th December, 1911, was allowed to stand through the night in "outside" water, and at 10 a.m. on 6th was squeezed into watch-glasses containing a little Berkefeld water, through 50 mesh bolting silk.

Aggregation commenced about 12 noon, and the watch-glasses were then placed in finger-bowls of Berkefeld water. Under the microscope no direct motion of the cells towards one another was noticeable. The cells gravitated downwards and adhered together to form small spherical nodules. These were shaken towards the centre of the watch-glass and left for the night.

On the morning of the 7th nearly all the stuff had united to form irregularly shaped plates from 1 to 2 mm. in length connected by narrow strands. In various spots there were club-headed vertical upgrowths from the plates. The whole aggregate, which was greenish yellow in colour, was surrounded with a tough perisarc, no space appearing between it and the contents.

By the 8th considerable contraction of the interior mass was noticed. There was a clear space between the perisarc and the contained matter, and clear spots were seen here and there in the plates. The contents of the club-headed upgrowths also contracted.

On the 9th these cultures were found swarming with Infusoria and Flagellates, and they were fixed in Corr. Sub. It was thought then that Protozoa would injure the culture; experience proved that they are not harmful.

Experiment 3.—Colonies of *Antennularia antennina* collected on 12th December, 1911, and kept 24 hours in Berkefeld water. Squeezed through 180 mesh bolting silk, 11 a.m., December. 13th. By 3 p.m. small spherical masses had formed. On the 14th no change had occurred, the small spheres forming a film over the bottom of the watch-glass. Microscopical examination showed cells with a broken outline; and small fragments, which might be portions of larger cells. This may very possibly result from pressure through such a small mesh as 180. This experiment gave no further results.

Experiment 4.—14th December. Squeezed a colony of *Antennularia antennina* that had lain for some weeks in a wooden tank in the Laboratory, through 50 mesh. No attempt at aggregation. Very probably the material had deteriorated.

Experiment 5.—19th December, 1911. Colonies of *Antennularia antennina* brought in from the Sound. Very dirty, and placed for the night in Berkefeld water. On 20th noon squeezed through 50-mesh bolting silk into watch-glasses. By 4.30 p.m. small masses had formed, mostly vertical to the bottom of the glass, but so far the cells not very coherent. By noon on the 21st numerous small masses surrounded with perisarc adherent to the glass.

Many of these masses gradually died off, without showing any marked change in shape. The contents, however, gradually contracted away from the perisarc, and finally died. Two small masses were alive on 20th January, 1912, 34 days from the commencement of the experiment. These were fixed for sectioning.

Experiment 8.—28th December. Colony of *Antennularia ramosa* squeezed through 50 mesh at 5 p.m. into outside water. By 11 a.m., 29th, many large masses formed, and adhering to the glass. On 30th the perisarc clearly defined, and the interior plasm slightly contracted away from it. These masses lived until 5th January, 1912, when they died.

Experiment 10.—12th January, 1912, 4 p.m. A very fine colony of *Antennularia ramosa* squeezed through 50 mesh into watch-glasses which were placed in bowls of outside water. A larger amount of material was used in this and subsequent cultures.

By 13th three large masses, between 3 and 4 mm. in length, had formed. They had not adhered to the glass, and the edges were rounded and turned over, somewhat resembling the helix of the human ear. The surface smooth, showing that perisarc had formed, and colour the characteristic yellowish green.

As time went on there was considerable contraction, and the edges became thicker. The cells appeared to migrate from the centre towards the edges, so leaving a thin central nearly clear plate, surrounded by thickened ridges. There was no sign of proliferation or budding of any kind, and by the 24th all three had lost the yellow colour, and looked grey and unhealthy. They were then fixed.

Experiment 13.—17th January, 1912, 4. p.m. Flourishing colony of *Antennularia ramosa* squeezed through 50 mesh and 180 mesh into watch-glasses. Allowed to settle for 3 hours, and then transferred to bowls of Berkefeld water.

18th, 10 a.m. All the 50-mesh cultures show typical lobate masses, but of smaller size than in Exp. 10. The masses from 180 mesh are smaller and lighter coloured. Pieces of tentacle and theca were observed, and removed. Small masses from each culture placed in finger-bowls containing about 450 c.c. Berkefeld water.

19th. All masses from 50 mesh have contracted greatly, and increased in length vertically. They are generally conical. In places the perisarc not formed. Colour, a healthy yellow. All adhered to the glass.

The culture from 180 mesh differs from above. Only small spherical masses have resulted, generally adhering to the glass. Perisarc has not yet been formed.

20th. Most of the masses have contracted further, but the majority are grey and unhealthy looking.

It may be noted that the Laboratory was particularly warm at this time, and the cultures were affected thereby.

24th. Most of the masses were dead, one or two remained alive until 31st. They showed no great change except contraction of the interior protoplasm away from the perisarc and slight attempts to form knobs or proliferations. These did not advance far, and the plasm soon contracted away from the surrounding perisarc. Certain of the masses were fixed for examination.

Experiment 15.—25th January, 1912. *Antennularia ramosa* squeezed through 50 mesh and *Antennularia antennina* through 180 mesh. Allowed to settle through the day.

26th. The 180-mesh culture has simply formed a film over the bottom of the glass—no masses have formed.

Numerous yellowish masses in the 50-mesh culture. Certain of these were transferred to finger-bowls of " outside " water. Generally they were not healthy in appearance, and a good deal of foreign matter was mixed with them.

28th. One mass remains healthy. Several lobes appear on it. The perisarc has formed, but is rougher than usual. A great many Infusoria in the cultures.

29th. The lobes have contracted into the main mass, which has also further contracted.

1st February. Still healthy in appearance. The contents have further contracted away from the perisarc. Fixed for examination.

Experiment 17.—31st January, 1912, noon. Squeezed colonies of *Antennularia ramosa* through 50 mesh, and placed in finger-bowls of Berkefeld water, 4 p.m. The temperature of the Laboratory is so high that these bowls were placed in a trough of running water.

1st February. Lobate masses, 1 to 2 mm. in length, surrounded by perisarc have formed.

2nd. The lobes have further contracted, and most of the masses are attached to the glass.

2nd to 11th. Very little change observable except slight contraction by which a space was left between the contents and the perisarc. Clearer spaces appeared also in the body of the mass.

20th. One mass now 20 days old and thoroughly healthy in appearance fixed.

21st. Several small masses still alive. In the largest of them contraction of the contents at various points has resulted in a markedly spongy appearance, as shown in the figure. This is observable in a less degree in other smaller masses.

9th March. All remained alive up to this date, and without any apparent change. From this date onward the contents appear to be gradually degenerating—in one or two of the masses the enclosing perisarc is almost empty.

21st. The spongy appearance of the large mass is gradually changing, and the contents appear to be concentrating in the centre. This culture is now 51 days old, and has still a healthy yellow colour. Similar concentration has taken place in one or two of the smaller masses which were fixed for examination.

Experiment 23.—1st March, 1912, 11 a.m. Squeezed fine colonies of *Antennularia ramosa* through 50 mesh. Aggregation of cells commenced almost immediately.

3rd. Of the three cultures made on the 1st, two are not healthy. Spherical masses have formed, but they look soft and flocculent, and the perisarc is not clear and smooth.

The third culture, however, has resulted in a healthy lobed mass, not attached to the glass—deep yellow in colour and with a smooth perisarc. The edges of this mass are folded over into knobbed ridges, round a thinner central plate. There is a nearly vertical cylindrical mass at one end.

13th. The edges have curled over more, and ten knobs on them are more accentuated. The centre plate thinner, and at points clear spaces appear.

15th. Cut off the end of the vertical projection.

16th. Perisarc had reformed round the cut end and the incised piece.

SUMMARY AND CONCLUSION.

1. The Hydroids experimented on were *Antennularia ramosa*, and *A. antennina*.
2. These were cut in pieces and pressed through bolting silk, with the result that isolated cells and small cell aggregates were obtained, which soon aggregated together to form compact masses.
3. These restitution masses secreted a perisarc within from 12 to 18 hours.
4. Various changes in shape, and general retraction of the mass away from the perisarc occurred later, but even up to 60 days there was no sign of the regeneration of the hydranths.
5. The restitution masses consisted of ectoderm and endoderm cells, and in addition such structures as nematocysts, ova, and broken down cells, all of which were subsequently absorbed and played no part in the future development. The ectoderm cells were relatively little damaged, and were embedded in a plasmodial mass formed by the endoderm cells.
6. A definite layer of ectoderm cells is formed on the surface, and these cells secrete the perisarc.
7. Gradual aggregation and segregation of the endoderm cells from the plasmodial mass takes place ; and they form very definite tubules similar in structure to the cœnosarcal tubules continuous with the enteric cavities of the normal hydranths. These tubules are embedded in a mass of ectoderm cells, they are convoluted and ramify in all directions. Many granules develop in the cytoplasm of these cells, and after about a month many of them have degenerated.
8. The ectodermal cells show no signs of degeneration, and the masses containing them have been kept alive for 60 days at the time of writing.
9. In none of the experiments was there any sign of the occurrence of cell division.

In conclusion, we can say that, experimenting on different species of Hydroids to those employed by Wilson, we have confirmed his results up to the stage of development at which the restitution mass is formed and the perisarc secreted. Beyond that our results differ ; in the species used by Wilson the restitution masses soon gave rise to hydranths, and practically complete new Hydroids were regenerated ; in the species of Antennularia used by us development of the restitution masses was much slower : they never regenerated hydranths, but gave rise to tumour-like masses of convoluted tubules lined with endodermal cells embedded in masses of irregularly arranged ectoderm cells. These masses remained alive for at least 60 days.

Our experiments have resulted in the production of masses that are certainly abnormal and pathological, but nevertheless we would submit that the segregation and rearrangement of the cells after isolation, and the comparatively long duration of life of the tumour-like masses to which they give rise are facts of considerable theoretical interest.

PLYMOUTH,
March 28th, 1912.

On F_2 *Echinus* Hybrids.

By

H. M. Fuchs.

An investigation on inheritance in hybrids between the three English species of *Echinus* was carried out in the Marine Biological Laboratory, Plymouth, during 1909–1912 by C. Shearer, W. de Morgan, and H. M. Fuchs. In a paper published in the *Phil. Trans. Royal Soc.*, Ser. B, Vol. CCIV., p. 255, the results of this work were described in detail. At the time of publication, *E. miliaris* had been raised from the egg to maturity in the laboratory, in the course of one year, and a second generation had been obtained from these individuals, but none of the hybrid urchins had as yet reached maturity. This year, however, some of the hybrids have become sexually mature, and from them a second hybrid generation has been raised.

The urchins which have formed ripe genital products are four individuals of the cross *E. esculentus* ♀ X *E. acutus* ♂ (referred to below as *EA*), derived from fertilizations made in 1912. The largest of these urchins now measures 6 cm. in diameter, exclusive of the spines. On May 11th, 1914, two of these hybrids laid eggs in the tank in which they were kept. Naturally these eggs could not be used for experimental purposes, since they were deposited in the sea-water of the aquarium circulation, and therefore not under sterile conditions. On June 6th I induced three of the four to deposit genital products without cutting them open, under conditions which excluded the possible presence of foreign eggs or spermatozoa. It is hardly necessary to mention here that, as in all the previous work on *Echinus* hybrids, the fact of the complete absence of such sperm was made certain by controls of unfertilized eggs, none of which segmented. Two of the three hybrids from which genital products were obtained proved to be females and one a male. The sperm from the latter gave 100% fertilizations with the eggs of the former, yielding healthy larvæ.

From this it is seen that hybrids between the species *E. esculentus* and *E. acutus* are perfectly fertile and that a healthy F_2 generation can be obtained from them. When a larger number of these F_1 hybrids have been reared, an examination of the characters of the fully grown urchins should decide whether the intermediate forms between the two species, which are found in the sea and which are quite fertile, are to be considered as hybrids or as extreme variants of one of the two species.

Besides making the cultures described above, I fertilized *E. miliaris* eggs with the sperm of the *EA* male, and used *E. miliaris* sperm to fertilize *EA* eggs. This was done in order to see whether the inheritance of the late larval characters (posterior epaulettes and green pigment) in these crosses would be the same as when pure *E. esculentus* or *E. acutus* was crossed with *E. miliaris*. Now, twenty-one cultures,* derived from fifteen fertilizations, have shown that the inheritance of these larval characters has this year been the same as it was in 1912 : the *E. esculentus* or *E. acutus* characters are developed in the hybrids in both reciprocal crosses with *E. miliaris*. It was found that the two reciprocal combinations of *EA* X *miliaris* likewise gave this result. From the cross *EA* ♀ X *miliaris* ♂ large numbers of vigorous fully formed plutei developed, and a number of these "triple-hybrids" have already passed through metamorphosis.

Unfortunately the F_2 generation obtained from the *E. esculentus* X *E. acutus* hybrids can give no information as to the inheritance of the late larval characters, since the latter are alike in the two species. It is the F_2 generation from hybrids between *E. esculentus* or *E. acutus* and *E. miliaris* that will give this valuable information, but none of these hybrids have as yet reached maturity. A small number of *E. miliaris* ♀ X *E. acutus* ♂ hybrids (of which the largest measured 2¼ cm. in diameter, exclusive of spines), from fertilizations made in May, 1912, were alive and healthy this summer. After having tried unsuccessfully to induce these to deposit eggs or sperm, I cut them open on June 6th of this year. They contained, however, only small and quite immature gonads.

As it must be some time before more *E. acutus* (or *E. esculentus*) X *E. miliaris* hybrids will have grown large enough to be mature, I wish to record these results up to date. The success in bringing the *EA* hybrids to maturity has been largely due to the care taken by Mr. A. J. Smith, head assistant at the Plymouth Laboratory, in attending to the cultures after metamorphosis. The investigation was made with the assistance of a grant from the Royal Society.

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* Some of these cultures were reared at Plymouth, others were transported as blastulæ to the Imperial College, London, and raised there in water which came from Lowestoft.

The Trematode Parasites of Fishes from the English Channel.

By

William Nicoll, M.A., D.Sc., M.D.

With Figures 1–6 in the Text.

In continuation of my researches on the entozoa of British marine fishes I spent two months (August and September, 1909) at the Plymouth Marine Biological Station. By the courtesy of the Government Grant Committee of the Royal Society, a table was placed at my disposal and all expenses in connection with the investigation were defrayed.

Hitherto few observations have been made upon entozoa from fishes of the south coast. The area, however, is of considerable interest from a faunistic point of view, for it contains several species of fish which are uncommon or unknown on other parts of our coast. In addition it is richer in species than either the east or the west coast. The influx of Mediterranean forms adds further interest.

During the course of these two months 419 fish belonging to 70 species were examined. Later, further consignments were sent to me in London. These comprised an additional 56 fish with an additional 9 species. The total number with which this investigation deals is therefore 475 fish and 79 different species. Amongst these, Acanthopterygian fishes figured most largely. The various groups were represented as follows :—

	Species.	Fishes.
Acanthopterygii	32	213
Pharyngognathi	6	50
Anacanthini	20	109
Physostomi	5	21
Lophobranchii	4	31
Elasmobranchii	12	51
Total . . .	79	475

Amongst these 79 species there were 37 which I had not previously had an opportunity of examining, and the majority of them afforded interesting new records.

Judging by those figures this is probably the largest and most representative investigation which has hitherto been made on this subject. A comparison with the numbers dealt with in my previous reports will perhaps be of interest. For St. Andrews, Millport, and Aberdeen the corresponding figures are as follows :—

	St. Andrews.		Millport.		Aberdeen.		Total.	
	Species.	Fishes.	Species.	Fishes.	Species.	Fishes.	Species.	Fishes
Acanthopterygii .	16	74	11	34	9	30	24	138
Pharyngognathi .	0	0	2	7	0	0	2	7
Anacanthini .	14	65	11	41	13	46	23	152
Physostomi .	6	50	3	8	3	4	8	62
Lophobranchii* .	2	2	2	2	0	0	3	4
Elasmobranchii .	3	5	2	2	0	0	5	7
Total .	41	196	31	94	25	80	65	370

From this it is evident that the material examined at Plymouth was richer, not only in the gross total examined, but also in the variety of specimens, than the corresponding material from the other three localities combined. Of the individual groups only the Anacanthini and Physostomi were not so well represented at Plymouth as in these other localities.

In these four series of investigations I have thus examined a total of 845 fish belonging to 102 different species, giving an average of a little over 8 fish of every species. Some specimens have naturally received more attention than others, and those most exhaustively dealt with have been the sprat (*Clupea sprattus*), the common dab (*Pleuronectes limanda*), *Lepadogaster gouanii*, *Ammodytes tobianus*, the mackerel (*Scomber scombrus*), and the butter fish (*Centronotus gunnellus*). Other fishes which have received a large measure of attention have been the horse-mackerel, the sea bream, the whiting, and the John Dory.

From these four localities the aggregate figures are :—

	Species.	Fishes.
Acanthopterygii	37	351
Pharyngognathi	5	50
Anacanthini	31	261
Physostomi	11	90
Lophobranchii*	5	35
Elasmobranchii	13	58
Total . . .	102	845

* The Sun-fish (*Mola mola*) is included here.

These 102 species represent practically all the marine fishes commonly occurring in British seas. Little more than 20 others have ever been recorded from the British coasts, and the majority of those only as isolated individuals.

Apart from these investigations only four species have been recorded in British waters as hosts of trematode parasites, namely, *Brama raii*, *Phycis blennoides*, *Raia radiata*, and *Trygon pastinacea*.

In addition to the four above-mentioned localities, the trematode parasites of marine fishes have been pretty exhaustively dealt with on the Northumberland coast by Miss Lebour and on the Lancashire coast by Johnstone and A. Scott. From these investigations a fairly comprehensive idea may be obtained of the trematode fauna inhabiting our marine fishes. It seems desirable, however, that further investigations should be made in such areas as the Bristol Channel, the north-west coast of Scotland, or the Hebrides, and the southern part of the North Sea (e.g. off Lowestoft). In particular it would be interesting to obtain information as to the trematode fauna of fishes from the coast of Ireland, a region still practically untouched.

Of the 475 fishes examined at Plymouth, 380 (80%) were infected with parasitic worms: 56% were infected with Trematodes, 44% with Cestodes, 48% with Nematodes, and 2% with Echinorhynchs.

It is interesting to compare these figures with those obtained in other areas. The comparison is shown in the following table:—

	Trematodes.	Cestodes.	Nematodes.	Echinorhynchs.	Total.
St. Andrews .	75%	54%	67%	8%	83%
Millport .	70%	46%	76%	13%	80%
Aberdeen .	51%	57%	58%	4%	91%
Plymouth .	56%	44%	48%	2%	80%
Total . .	60%	47%	56%	5%	81%

This table shows that although the percentage of infected fishes in the Plymouth area is only slightly less than that in the other areas, yet the variety of parasites in each fish is considerably less. It will be seen that the Plymouth figures are less in every case than those of other areas with the single exception of the incidence of Trematodes in the Aberdeen fishes.

In the present report only the trematode parasites are dealt with. Over 50 different species were collected, and these represent about three-fifths of the total number of Trematodes known to occur in British marine fishes. The most interesting of these have already been described in a previous paper (Nicoll, 1913*a*).

At the end of this report a list is given of the fishes examined at Plymouth, with the trematode parasites which were obtained from them.

I have to thank Dr. E. J. Allen, Director of the Plymouth Marine Laboratory and his assistant, Mr. A. J. Smith, for their unfailing courtesy and help.

LIST OF SPECIES DEALT WITH IN THIS REPORT.

DIGENEA.

DISTOMATA PROSOSTOMATA.

Family **ALLOCREADIIDAE.**

Sub-Family ALLOCREADIINAE.

Genus **Podocotyle** (Dujardin).

1. *P. atomon* (Rud.).
2. *P. reflexa* (Crepl.).
3. *P. syngnathi* Nicoll.
4. *P. atherinae* sp. inq.

Genus **Lebouria** Nicoll.

5. *L. varia* Nicoll.
6. *L. alacris* (Looss).

Genus **Peracreadium** Nicoll.

7. *P. genu* (Olsson).
8. *P. commune* (Olsson).

Genus **Cainocreadium** Nicoll.

9. *C. labracis* (Dujardin).

Genus **Helicometra** Odhner.

10. *H. pulchella* (Rud.).

Sub-Family STEPHANOCHASMINAE.

Genus **Stephanochasmus** Looss.

11. *S. pristis* (Deslongch).
12. *S. caducus* Looss, var. *lusci*.
13. *S. cesticillus* (Molin).

Sub-Family LEPOCREADIINAE.

Genus **Lepidapedon** Stafford.

14. *L. rachion* (Cobbold).

Genus **Pharyngora** Lebour.

15. *P. bacillaris* (Molin).

Genus **Lepidauchen** Nicoll.

16. *L. stenostoma* Nicoll.

Family **FELLODISTOMIDAE.**

Sub-Family FELLODISTOMINAE.

Genus **Steringotrema** Odhner.

17. *S. cluthense* (Nicoll).
18. *S. divergens* (Rud.).
19. *S. pagelli* (v. Ben.).

Genus **Bacciger** n.g.

20. *B. bacciger* (Rud.).

Sub-Family HAPLOCLADINAE.

Genus **Tergestia** Stossich.

21. *T. laticollis* (Rud.).

Family **ZOOGONIDAE.**

Sub-Family ZOOGONINAE.

Genus **Zoogonoides** Odhner.

22. *Z. viviparus* (Olsson).

Genus **Zoonogenus** Nicoll.

23. *Z. vividus* Nicoll.

Family **MONORCHIDAE.**

Sub-Family MONORCHINAE.

Genus **Monorchis** (Monticelli).

24. *M. monorchis* (Stossich).

Family **HAPLOPORIDAE.**

Genus **Haploporus** Looss.

25. *H. benedeni* (Stossich).

Genus **Saccocoelium** Looss.
26. *S. obesum* Looss.

Family **AZYGIIDAE**.

Genus **Ptychogonimus** Lühe.
27. *P. megastomus* (Rud.).

Family **HEMIURIDAE**.

Sub-Family HEMIURINAE.

Genus **Hemiurus** Rud.
28. *H. communis* Odhner.
29. *H. ocreatus* (Rud.).

Sub-Family DINURINAE.

Genus **Lecithocladium** Lühe.
30. *L. excisum* (Rud.).

Sub-Family STERRHURINAE.

Genus **Lecithochirium** Lühe.
31. *L. rufoviride* (Rud.).

Genus **Synaptobothrium** (v. Linstow).
32. *S. caudiporum* (Rud.).

Sub-Family LECITHASTERINAE.

Genus **Lecithaster** Lühe.
33. *L. gibbosus* (Rud.).

Sub-Family SYNCOELIINAE.

Genus **Derogenes** Lühe.
34. *D. varicus* (Müller).

Genus **Hemipera** Nicoll.
35. *H. ovocaudata* Nicoll.

Genus **Derogenoides** Nicoll.
36. *D. ovacutus* Nicoll.

Family **(BUNODERIDAE)**.

Genus **Bunodera** Railliet.
37. *B. nodulosa* (Zeder).

Family (**ACANTHOCHASMIDAE**).

Genus **Acanthochasmus** Looss.
38. *A. imbutiformis* (Molin).

DISTOMATA GASTEROSTOMATA.

Family **BUCEPHALIDAE**.

Sub-Family Bucephalinae.

Genus **Bucephalus** Baer.
39. *B. minimus* (Stossich)

Genus **Bucephalopsis** (Diesing).
40. *B. gracilescens* (Rud.).

Genus **Rhipidocotyle** Diesing.
41. *R. minima* (Wagener)
42. *R. viperae* (v. Ben.).

Sub-Family Prosorhynchinae.

Genus **Prosorhynchus** (Odhner).
43. *P. crucibulum* (Rud.).
44. *P. aculeatus* Odhner.
45. *P. triglae* sp. inq.
46. *P. squamatus* Odhner.

MONOGENEA.

Genus **Microcotyle** v. Ben. & Hesse.
47. *M. draconis* Briot.

Genus **Axine** Abildgaard.
48. *A. belones* Abildg.

Genus **Octobothrium** F. S. Leuckart.
49. *O. merlangi* (Kuhn).

Genus **Octocotyle** Diesing.
50. *O. scombri* Kuhn.

Genus **Pseudocotyle** v. Ben. & Hesse.

51. *P. squatinae* v. Ben. & Hesse.

Genus **Calicotyle** Diesing.

52. *C. kroyeri* Diesing.

DIGENEA.

DISTOMATA PROSOSTOMATA.

Family **ALLOCREADIIDAE.**

Sub-Family Allocreadiinae.

Genus PODOCOTYLE (Dujardin).

Podocotyle atomon (Rud.).

Odhner, 1905, pp. 320–6.
Lebour, 1908, pp. 26–27.

This parasite was obtained from ten species of fish, namely, *Gobius ruthensparri*, *Centronotus gunnellus*, *Cottus bubalis*, *Cyclogaster montagui*, *Gastraea spinachia*, *Gadus merlangus*, *Pleuronectes flesus*, *Zeugopterus norvegicus*, *Nerophis aequoreus*, and *Anguilla vulgaris*. This is the first record of its occurrence in the pipe-fish (*Nerophis*).

Podocotyle reflexa (Creplin).

Odhner, 1905, p. 326.

This species was obtained from the intestine of *Gastraea spinachia* and *Onos mustela* on several occasions. It is distinguished from the previous species by its much longer cirrus-pouch and the interrupted arrangement of its yolk glands. The limits fixed by Odhner for the size of this species are too narrow, as mature specimens little over 1 mm. in length were found in *Onos mustela*. It is extremely difficult to differentiate such small specimens from *P. atomon*.

Podocotyle syngnathi Nicoll.

Nicoll, 1913a, pp. 238–40.

This species was frequently found in the pipe-fishes, *Syngnathus acus*, *Siphonostoma typhle* and *Nerophis aequoreus*.

(Podocotyle) atherinae sp. inq. (Fig. 1).

A single specimen of a species of "*Podocotyle*" was obtained from the anterior part of the intestine of *Atherina presbyter*. I am unable to refer it to any known species, and it is doubtful even if it can be included in the genus *Podocotyle*. It is a small, somewhat flattened form measuring 1·1 mm. in length by ·49 mm. in greatest breadth, and it is of a dark grey colour in life. The outline is roughly oval with a slightly attenuated neck.

The oral sucker is globular with a diameter of ·13 mm. The ventral sucker is transversely oval and measures ·21 × ·28 mm. The latter is situated ·46 mm. from the anterior end. The pharynx is contiguous with the oral sucker and has a diameter of ·07 mm. The œsophagus is ·11 mm. long, and the wide diverticula extend nearly to the posterior end of the body.

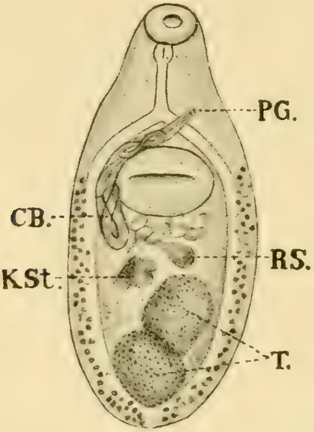

Fig. 1.—(*Podocotyle*) *atherinae*. Ventral view × 50. C.B. Cirrus-pouch; K.St. Ovary; P.G. Genital aperture; R.S. Receptaculum seminis; T. Testes. *G. Roberts del.*

The genital aperture is on the left side a little in front of the level of the intestinal bifurcation. The cirrus-pouch is long and slender, and reaches to the level of the ovary. It contains a long, convoluted vesicula seminalis. The ductus is simple. The testes lie near the posterior end of the body. The distance between the posterior testis and the tip of the tail being ·13 mm. They are contiguous and oblique, the anterior being on the left. Their outline is irregularly globular, and their margins are entire. The posterior testis lies closely apposed to the right intestinal diverticulum, while the anterior one is apposed to the left diverticulum. Their greatest diameter is about ·17 mm.

The ovary lies to the right of the anterior testis and a little in advance of it, the two being almost contiguous. It is a distinctly trilobate body, the lobes being directed backwards, and its greatest diameter is ·13 mm. It is separated from the ventral sucker by a space of ·14 mm. The medium-sized, pear-shaped receptaculum seminis lies immediately in front of the anterior testis. The yolk glands are moderately developed. They are almost entirely marginal, their anterior limit being the level of the ventral sucker. They fill up a considerable part of the post-testicular space, but do not unite. Behind the ovary a few follicles are found on the inner side of the right intestinal diverticulum, while on the left a few are found internal to the diverticulum on the level of the posterior testis. The scanty ova measure ·069–·072 × ·036 mm., and are provided with a minute knob-like process at their anopercular pole.

In referring this form to the genus *Podocotyle* rather than to any of the other genera of the sub-family one is influenced by the characteristic shape of the ovary, the position of the genital aperture and the length of the cirrus-pouch. The position of the testes is the chief contradictory feature, and in this respect the species bears a closer resemblance to *Lebouria*. It might be suggested that it is an abnormal specimen of *P. atomon* in which the testes have become displaced, but as I have no previous experience of such an abnormality I am very doubtful if this could be the case.

Genus LEBOURIA Nicoll.

Lebouria alacris (Looss).

Nicoll, 1910, pp. 332–4.

This species was frequently obtained from the smaller Labridae (*Ctenolabrus rupestris*, *Centrolabrus exoletus* and *Crenilabrus melops*). A single specimen was also found in the intestine of *Labrus berggylta*.

Lebouria varia Nicoll.

Nicoll, 1910, pp. 329–32.

This species was only met with in the dragonet (*Callionymus lyra*), in which it is fairly common.

Genus PERACREADIUM Nicoll.

Peracreadium commune (Olsson).

Nicoll, 1910, pp. 328–9.

Only three specimens of this species were met with in *Labrus berggylta* and *Crenilabrus melops*. They agree with my previous description, except that the ventral sucker is somewhat larger and more globular than in the Clyde specimens. It is thus not a feature to distinguish this species from *P. genu.*

Peracreadium genu (Rud.).

Nicoll, 1910, pp. 326–8.

This was obtained twice from the intestine of *Labrus berggylta*, but never from any of the other *Labridae* (over 30 were examined). A single immature specimen, however, occurred in the intestine of a shanny (*Blennius pholis*). It was only ·4 mm. long. The testes were oblique, and the ovary on the right side of the anterior testis. The cirrus-pouch reached almost to the ovary. The yolk glands were not visible, and there were no ova. It seemed impossible to determine whether this specimen should be regarded as *P. genu* or *P. commune*, but in any case it must be regarded as an adventitious parasite of the shanny.

Genus CAINOCREADIUM Nicoll.

Cainocreadium labracis (Dujardin).

Johnstone, 1908, pp. 44–53.

Half a dozen specimens of this species were taken from the intestine of the only bass (*Labrax lupus*) examined.

Genus HELICOMETRA Odhner.

Helicometra pulchella (Rud.).

This was by far the commonest member of the *Allocreadiidae* met with. As a parasite of littoral fishes it largely replaces *Podocotyle atomon*, which is predominant on the east coast. At Plymouth it was met with in twelve different hosts : *Serranus cabrilla*, *Trigla pini*, *Gobius paganellus*, *Blennius pholis*, *Blennius gattorugine*, *Lepadogaster gouanii*, *Labrus mixtus*, *Labrus berggylta*, *Ctenolabrus rupestris*, *Zeugopterus punctatus*, *Anguilla vulgarus* and *Conger conger*. Ninety specimens of these fishes were examined, and the parasite was met with thirty-three times (i.e. 3 in 8). Its chief hosts are the goby and the blennies. In these it occurred three times in five.

A fairly full description, partly based on the material collected at Plymouth, has already been given (Nicoll, 1910, pp. 335–40). The distribution of this species is rather noteworthy. It has been recorded from the Mediterranean, from the English Channel and from the west coast of Scotland. It has never been recorded from the North Sea.

H. pulchella (Rud.) of Odhner (1902) from Northern fishes, is probably a distinct species.

Sub-Family Stephanochasminae.

Genus STEPHANOCHASMUS Looss.

Stephanochasmus caducus Looss var. *lusci.*

Numerous young specimens of a parasite which I can only with some doubt identify as this species were taken on two occasions from the duodenum and pyloric caeca of *Gadus luscus.* A single immature specimen was also found in the caeca of *Gadus minutus.*

They measure 1·5–3 mm. in length, and most of those over 2 mm. contained ova. The cephalic spines are arranged in two rows of 25 each, and those of the anterior row are shorter than those of the posterior row, ·019 mm. and ·021 mm. respectively. In a 3 mm. species the oral sucker has a diameter of ·12 mm. and the ventral ·14 mm. The latter is situated ·63 mm. from the anterior end. The prepharynx is ·21 mm. long, and the pharynx measures ·1 × ·08 mm.

The cirrus-pouch extends ·49 mm. behind the ventral sucker. The vagina joins it behind the sucker, and the genital sinus is ·2 mm. long. The ovary, testes and yolk glands are situated as described by Looss, but the yolk glands extend forward a short distance in front of the end of the cirrus-pouch. The few ova measure ·066 × ·036 mm.

The chief respects in which these specimens differ from Looss's description (1901, p. 603) are the number and size of the cephalic spines, the position of the ventral sucker, the inequality of the suckers and the greater extent of the yolk glands. It seems possible to ascribe the first two of these to difference in age and size of the specimens (Looss's description was from specimens over 4 mm. long). The other two features, together with the difference in number of the cephalic spines, do not seem of sufficient importance to warrant establishing a new species, but it seems advisable to regard this form as a distinct variety.

It is interesting to note that the specimen obtained by Miss Lebour (1908, p. 36) from the whiting (*Gadus merlangus*) does not entirely agree with Looss's description of *S. caducus.* The suckers are nearly twice as great as those of Looss's form. The yolk glands are more extensive and the eggs are larger. It is possible that this may represent a third variety of the same species.

Stephanochasmus cesticillus (Molin).

Looss, 1901, pp. 598–9.

Four specimens of this parasite were collected from the stomach and intestine of *Zeus faber.* This is the first and only time this parasite has been recorded from British waters, and it is the only occasion on which it has been met with in this host.

Sub-Family Lepocreadiinae.

Genus LEPIDAPEDON Stafford.

Lepidapedon rachion (Cobbold).

Odhner, 1905, pp. 332–7 (*Lepodora rachiaea*).
Lebour, 1908, pp. 29–30.

This was found frequently in the intestine of the pollack (*Gadus pollachius*) once in considerable numbers. It was not met with in any of the other Gadoids, of which nearly 40 were examined.

Lepidauchen stenostoma Nicoll.

Nicoll, 1913a, pp. 240–1.

Two specimens were obtained from the intestine of *Labrus berggylta*. This species has already been fully described.

Genus PHARYNGORA Lebour.

Pharyngora bacillaris (Molin).

Nicoll, 1910, pp. 341–7.

This parasite was met with very frequently in the intestine of *Scomber scombrus*, *Gadus merlangus*, *Capros aper* and *Cyclopterus lumpus*. Only one specimen of the last-mentioned fish was examined (22nd April, 1910), and it contained several thousand immature specimens ranging in length from ·6 mm. to 1·8 mm. I have previously recorded the occurrence of this parasite in the lumpsucker caught in St. Andrews Bay (1909, p. 22, *Distomum* sp.). In that case, too, the parasites were all immature, though very much fewer in number. In *Capros aper*, also, although I have found the parasite in moderate numbers on four occasions, they have always been immature. Only in the mackerel and whiting have fully mature specimens been obtained. The mackerel is undoubtedly the commonest host of this parasite.

Family **FELLODISTOMIDAE.**

Sub-Family Fellodistominae.

Genus STERINGOTREMA Odhner.

Steringotrema cluthense (Nicoll).

Nicoll, 1909, pp. 472–5.

This species was the commonest member of the family Fellodistomidae found on the south coast, and indeed the only one met with in Pleuronectid fishes. It was found in five out of thirteen specimens of *Pleuronectes limanda* and *P. microcephalus.* It has already been recorded in the latter host from the Firth of Clyde, but it is worthy of note that it has not been met with in the North Sea, although over 100 specimens of these two hosts have been examined. It has already been fully described.

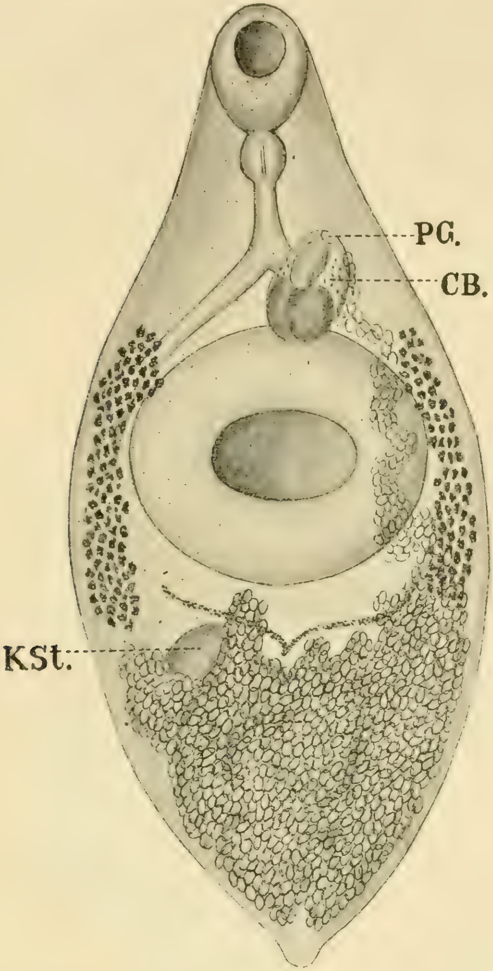

FIG. 2.—*Steringotrema pagelli.* Ventral view ×33. C.B. Cirrus-pouch; K.St. Ovary; P.G. Genital aperture. *M. Rhodes del.*

Steringotrema divergens (Rud.).

Odhner, 1911, p. 103.

This species was met with in fairly large numbers on two occasions (15th and 24th June, 1910) in *Blennius ocellaris.* It has hitherto only been recorded from the Mediterranean Sea and only in this host.

Compared with Odhner's description the ventral sucker in my specimens is less anisodiametric. The ratio of the two diameters being 6 : 7 instead of 6 : 8. The œsophagus is more contracted and wider, while the intestinal diverticula do not reach the middle of the testes. The ovary shows slight indentation, giving it a somewhat indistinctly trilobate appearance.

Steringotrema pagelli (van Beneden) (Fig. 2).

Odhner, 1911, p. 102.

A few specimens of this species were collected from the intestine of a sea-bream (*Sparus centrodontus*) obtained from Billingsgate Market, London (19th June, 1912). It was not possible to ascertain whether the fish was captured in the North Sea or in the English Channel. When collected the specimens were already dead and somewhat macerated. They were of a dull grey colour and remarkable for their great thickness and the unusual size and prominence of the ventral sucker.

The specimens measure 3·6–4·1 mm. in length with a greatest breadth of 1·6–1·8 mm. Both ends of the body are pointed. The oral sucker, which in every case is elongated, measures about ·48 × ·39 mm. in a specimen 3·8 mm. long. The ventral sucker, circular or transversely oval in outline, measures 1·05 × 1·16 mm., so that the ratio is not quite as much as 3 : 1. The distance of the centre of the ventral sucker from the anterior end is about 1·8 mm.; it thus lies a little in front of the middle of the body.

The pharynx has a diameter of ·17 mm., and the œsophagus is somewhat longer. The intestinal diverticula diverge widely. Their ends are obscured by the great mass of ova.

The ovary and testes are also almost completely hidden by the uterus. The cirrus-pouch is a long bulbous structure lying immediately in front of the ventral sucker, which it touches. The aperture is on the level of the intestinal bifurcation and about midway between it and the left margin of the body. The vesicula seminalis is of comparatively large size.

The yolk glands are situated at the sides of the ventral sucker and extend a short distance both in front of and behind it. Their extent is more limited than in *S. cluthense*. The uterus is very firmly packed and fills almost the whole of the post-acetabular region. The ova have thick brown shells and measure ·057–·063 × ·033–·037 mm. Their measurements are considerably larger than those found by Odhner for the same species.

Genus BACCIGER n.g.

Bacciger bacciger (Rud., Stoss., 1889) (Fig. 3).

On two occasions a single specimen of a small distome was found in the stomach of *Atherina presbyter*. The fish were received in London from Plymouth, and on that account the viscera were somewhat decomposed and the parasites badly preserved. From what could be made out of their anatomy, however, they appear to be either identical with or very closely related to *Distomum baccigerum* (Rud.) Stossich from *Atherina hepsetus*.

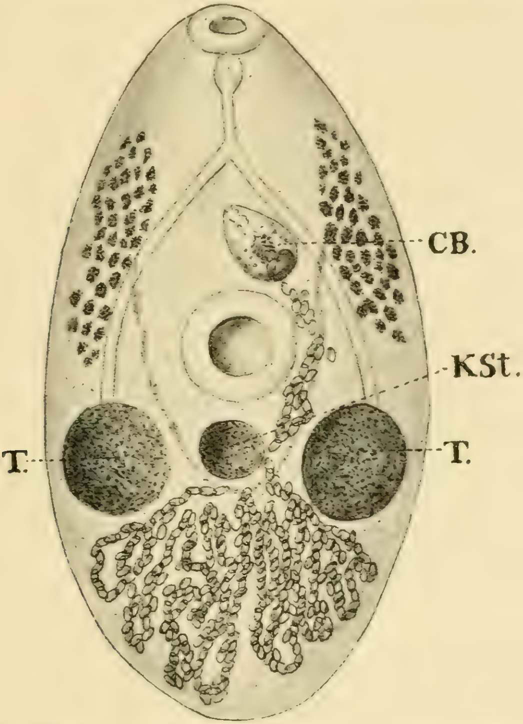

FIG. 3.—*Bacciger bacciger*. Ventral view × 100. C.B. Cirrus-pouch; K.St. Ovary; T. Testes. *G. Roberts del.*

The body is flat and of oval outline. The cuticule is unarmed. The length of the body (slightly pressed) is ·95 mm., and the maximum breadth in the middle, ·52 mm. The sub-terminal oral sucker has a diameter of ·105 mm., and the ventral sucker, situated a little in front of the middle of the body, measures ·15 mm. There is a small pharynx, contiguous in the oral sucker. The œsophagus is two or three times as long as the pharynx, the intestinal bifurcation taking place about midway between the pharynx and the genital aperture. The intestinal diverticula are very narrow, they extend into the posterior part of the body, but their termination is obscured by the uterus.

The genital aperture is median, and lies about ·15 mm. in front of the ventral sucker. There is a small, stout cirrus-pouch lying entirely in front of but almost touching the ventral sucker. At its posterior end it contains a small, simple vesicula seminalis. This is followed by a short inflated pars prostatica. The ductus ejaculatorius is short and wide and its walls are thrown into irregular folds, resembling the condition in *Steringophorus.* The testes are symmetrically situated, one on each side of the body, immediately behind the ventral sucker. They are globular or elongated oval bodies a little larger than the ventral sucker.

The ovary is situated between the testes, directly behind the ventral sucker. It is globular and somewhat smaller than the testes. The yolk glands occupy the sides of the body in front of the ventral sucker, and they extend from the middle of the sucker to the level of the œsophagus. The yolk ducts run backwards and unite behind the ovary. The uterus is confined entirely behind the testes. It forms a large number of narrow convolutions chiefly in a longitudinal direction. The initial convolutions are on the left side of the body, where the eggs are almost colourless. Towards the other side the colour gradually deepens. The vagina is apparently simple. The numerous eggs measure ·020–·024 × ·014–·017 mm.

In Stossich's figure the intestinal bifurcation is much nearer the ventral sucker than is the case in my specimens; the testes are much larger and the cirrus-pouch is not shown. The genital aperture also is described as being immediately behind the pharynx. How far these discrepancies are due to errors of observation it is impossible to say, as I have had no opportunity of examining Stossich's original material.

This species undoubtedly represents the type of a distinct genus of the family FELLODISTOMIDAE and the sub-family FELLODISTOMINAE. Its general build rather suggests an affinity with the *Monorchidae*, but the structure of the cirrus-pouch and vagina excludes it from that family.

Sub-Family Haplocladinae.

Genus TERGESTIA Stossich.

Tergestia laticollis (Molin).

Odhner, 1911, p. 111–13; Nicoll, 1913b, pp. 192–3.

This species was found frequently in the intestine of the horse-mackerel (*Trachurus trachurus*). It occurs occasionally in fairly large numbers, though as a rule only a few specimens are present in one host. It appears to be an exclusive parasite of this host.

Family **ZOOGONIDAE.**

Sub-Family Zoogoninae.

Genus ZOOGONOIDES Odhner.

Zoogonoides viviparus (Olsson).

Odhner, 1902a, p. 62; Nicoll, 1907, p. 83.

This very common parasite has already been recorded from eight species of British fishes. An additional five have here to be noted, namely, *Zeus faber*, *Blennius gattorugine*, *B. ocellaris*, *Solea vulgaris*, *S. variegata*. It was also found in *Callionymus lyra*, *Pleuronectes limanda*, *P. microcephalus* and *P. platessa*. The chief hosts of this parasite are undoubtedly *Callionymus lyra*, *Pleuronectes spp.* and *Solea spp.* It is rather curious that it has never once been recorded from Gadoid fishes or from the Labridae. It is worth remarking that the specimens I obtained from the cat-fish (*Anarrhichas lupus*) at St. Andrews belong to this species and not to the more recently discovered *Z. subaequiporus* Odhner, from the same host.

Genus ZOONOGENUS Nicoll.

Zoonogenus vividus Nicoll.

Nicoll, 1912, pp. 200–2.

A species which I have already described was met with frequently in the intestine of *Sparus centrodontus*. As I have previously remarked, it is an extremely delicate species and exceedingly difficult to preserve in a satisfactory state. An additional six bream obtained from Billingsgate Market were examined in June, 1912, but they were not infected with the parasite.

Family **MONORCHIDAE.**

Sub-Family MONORCHINAE.

Genus MONORCHIS Monticelli.

Monorchis monorchis (Stossich).

Looss, 1902b, pp. 117–18.

A couple of specimens of this parasite were found in the intestine of *Blennius gattorugine.*

Family **HAPLOPORIDAE.**

Genus SACCOCOELIUM Looss.

Saccocoelium obesum Looss.

Looss, 1902a, pp. 140–1.

A few specimens of this parasite were found in the intestine of a grey mullet (*Mugil chelo*).

Genus HAPLOPORUS Looss.

Haploporus benedeni (Stossich).

Looss, 1902a, pp. 136–8.

A few specimens were obtained from the intestine of a grey mullet (*Mugil chelo*) along with specimens of *Saccocoelium obesum.*

Family **AZYGIIDAE.**

Genus PTYCHOGONIMUS Lühe.

Ptychogonimus megastomus (Rud.).

Jacoby, 1899, pp. 16–24 ; Jägerskiöld, 1900, pp. 68–74.

This parasite was obtained from the stomach of four out of six specimens of *Mustelus vulgaris.* It usually occurred in moderate numbers.

Family **HEMIURIDAE.**

Sub-Family HEMIURINAE.

Genus HEMIURUS (Rud.).

Hemiurus communis Odhner.

Odhner, 1905, p. 351 ; Lebour, 1908, p. 46.

This exceedingly common and widespread fish parasite was met with in sixteen different species of fish, namely, *Sparus centrodontus, Capros aper, Lophius piscatorius, Cottus bubalis, Trigla pini, T. gurnardus, Gobius paganellus, Lepadogaster gouanii, Gadus luscus, G. merlangus, G. minutus, G. pollachius, Ammodytes lanceolatus, Molva molva, Zeugop-*

terus punctatus and *Nerophis aequoreus.* The species is now known to occur in thirty species of British marine fishes, and it is, with the exception of *Derogenes varicus*, the most widely distributed of all British fish parasites. In the above list the bream (*Sparus centrodontus*) from which the parasites were obtained were bought in the London market, so that their actual origin is unknown. None of the bream examined at Plymouth harboured the parasite.

Although so widely distributed, the parasite shows a distinct preference for Gadoid fishes, of which eleven species have been found to harbour it. I have myself examined over 120 Gadoids and found the parasite in 34% of them. Amongst the total number of other fishes which I have examined it has been present in less than 5%. Next to the Gadoids, *Cottus bubalis* and *Hippoglossus vulgaris* are probably the most frequent hosts.

Hemiurus ocreatus (Rud.).

=H. LUHEI Odhner.

Odhner, 1905, p. 352 ; Nicoll, 1909, pp. 21–2.

By far the commonest host of this parasite was found to be the pilchard (*Clupea pilchardus*). It was also met with on one occasion in each of the following hosts : *Trachurus trachurus, Capros aper, Scomber scombrus, Gadus merlangus,* and *G. pollachius.*

Sub-Family (DINURINAE).

Genus LECITHOCLADIUM Lühe.

Lecithocladium excisum (Rud.).

Looss, 1907, pp. 131–2.

This species was found only in the stomach of the mackerel (*Scomber scombrus*). It occurred in three out of eight specimens examined.

Sub-Family STERRHURINAE.

Genus LECITHOCHIRIUM Lühe.

Lecithochirium rufoviride (Rud.).

Looss, 1907, p. 147.

This was found in the stomach of the common eel (*Anguilla vulgaris*), the conger (*Conger conger*) and the angler (*Lophius piscatorius*). It is an extremely common parasite of the first two fishes, but has not previously been recorded from *Lophius.* Looss regards the conger as the only authentic host of the parasite, but there is no doubt that the single specimen I have obtained from *Lophius* really belongs to this species. It is about 5 mm. in length and has suckers measuring respectively ·65 mm. and ·78 mm. in diameter.

The encysted stage of this parasite was met with frequently in the shanny (*Blennius pholis*). It occurred in fairly large opaque brown cysts measuring ·7–1·4 mm. in diameter. They were attached to various abdominal viscera, but chiefly the intestine and the liver. They were commonest in the intestinal wall, either loosely attached or firmly embedded, and in more than one case free larvæ were found actually in the intestine. The larvæ when freed from the cyst were about 2 mm. in length (*ecsoma retracted*), and they had suckers measuring ·28 mm. and ·4 mm. respectively in diameter. The genital organs were well developed and fairly numerous eggs were present in many. These measured ·015 × ·009 mm.

The occurrence of the larvæ of *Lecithochirium gravidum* encysted in pipe-fishes has already been recorded by Looss (1907, p. 148).

Genus SYNAPTOBOTHRIUM von Linstow.

Synaptobothrium caudiporum (Rud.).

Looss, 1907, pp. 150–2.

This parasite has not hitherto been recorded from British waters. It occurred in the stomach of three out of five specimens of *Trigla hirundo* and once in *Zeus faber* and *Lophius piscatorius*. The specimens are considerably larger than those examined by Looss, reaching a length of 4 mm. (unpressed specimens) or 5 mm. (pressed specimens). The vesicula seminalis is confined entirely in front of the ventral sucker, while the metraterm may reach the centre of the sucker. The eggs have the characteristic shape described by Looss.

Encysted larvæ of this specimen were found along with those of *Lecithochirium rufoviride* in the liver and intestinal wall of a small specimen of *Labrus berggylta*, and two cysts were found in the intestinal wall of *Crenilabrus melops*.

Sub-Family Lecithasterinae.

Genus LECITHASTER Lühe.

Lecithaster gibbosus (Rud.).

Looss, 1907, p. 164 ; Odhner, 1905, pp. 356–8 ; Nicoll, 1909, pp. 18–20.

This parasite occurred in seven different hosts, namely, *Serranus cabrilla*, *Trachurus trachurus*, *Zeus faber*, *Trachinus vipera*, *Trigla pini*, *Gadus merlangus*, and *Zeugopterus norvegicus*. Though fairly widespread, it is by no means a common parasite, and its numbers in any particular host rarely exceed two or three.

Sub-Family SYNCOELIINAE.

Genus DEROGENES Lühe.

Derogenes varicus (O. F. Müller).

Odhner, 1905, pp. 360–4 ; Johnstone, 1907, pp. 188–92 ;
Lebour, 1908, pp. 45–6.

By far the commonest of marine fish parasites, this species was found in the stomach of twenty-eight different hosts, namely, *Mullus barbatus*, *Sparus centrodontus*, *Trachurus trachurus*, *Capros aper*, *Zeus faber*, *Trachinus vipera*, *T. draco*, *Lophius piscatorius*, *Cottus bubalis*, *Agonus cataphractus*, *Callionymus lyra*, *Trigla pini*, *T. gurnardus*, *T. hirundo*, *Cyclopterus lumpus*, *Blennius ocellaris*, *Gadus luscus*, *G. minutus*, *G. merlangus*, *G. pollachius*, *Molva molva*, *Onos tricirratus*, *Bothus maximus*, *Pleuronectes flesus*, *P. limanda*, *Solea vulgaris*, *Salmo trutta*, and *Conger conger*.

Genus HEMIPERA Nicoll.

Hemipera ovocaudata Nicoll.

Nicoll, 1913a, pp. 242–3.

This species was found a few times in the stomach of *Lepadogaster gouanii*.

Genus DEROGENOIDES Nicoll.

Derogenoides ovacutus Nicoll.

Nicoll, 1913a, pp. 243–6.

This parasite was met with only once in the stomach of a weever, *Trachinus draco*.

Family BUNODERIDAE.

Genus BUNODERA Railliet.

Bunodera nodulosa (Zeder).

Looss, 1894, pp. 33–41.

A few specimens of this species were obtained from the intestine of a trout (*Salmo trutta*) from the River Yealm.

Family **ACANTHOCHASMIDAE.**

Genus ACANTHOCHASMUS Looss.

Acanthochasmus imbutiformis (Molin).

Looss, 1901, pp. 632–3 ; Johnstone, 1906, pp. 177–9.

About thirty specimens of this parasite were found in the intestine of *Labrax lupus.*

What appears to be the larval stage of this parasite was found encysted in the gills of the pipe-fish, *Siphonostoma typhle.* A single cyst containing a living larva was also found on one occasion amongst the stomach contents of a whiting (*Gadus merlangus*).

The cysts in the gills of *Siphonostoma* are oval and measure ·3–·65 mm. in length. The oral sucker is slightly larger than the ventral, and is surrounded by eighteen cephalic spines. The cyst in the whiting had a diameter of ·38 mm. and the cercaria a length of 1·5 mm. The oral sucker measured ·15 mm. and the ventral ·17 mm. The cephalic spines numbered eighteen and measured ·056 mm. in length.

GASTEROSTOMATA.

Of this sub-order eight different species were collected, only one of which appears to be hitherto undescribed. A remarkable feature of this group is the great variation in the anatomical topography which may occur, even within specific limits. This variation affects chiefly the position of the genital glands and of the mouth. The size of the excretory vesicle also varies considerably. On the other hand, the position of the yolk glands and the size of the cirrus-pouch are fairly constant.

The variation is particularly well illustrated in the case of *Prosorhynchus crucibulum* (Rud.), in which as regards the position of the genital glands no two descriptions have yet agreed. It has been pointed out (Nicoll, 1910) that these discrepancies are due to the extreme variation in the position of the genital glands in this species. A similar, but less extensive, variation is found in *Prosorhynchus aculeatus* Odhner.

Within generic limits a still wider variation may be observed. In illustration it is sufficient to compare the condition in *Prosorhynchus squamatus* Odhner with that in *P. aculeatus.* In the former the ovary and testes lie almost directly one behind the other, along the right margin of the middle part of the body. In *P. aculeatus*, on the other hand, they are disposed in a triangle in the posterior part of the body, the ovary being in front and the testes lying one on each side of the body.

In the prosostomate distomes we are accustomed to regard the relative position of the genital glands as constant within narrow limits for the same species, and any such difference as exists between *P. squamatus* and *P. aculeatus* would be sufficient to warrant generic separation. In the Gasterostomata, however, it is evident that one cannot regard this feature as a satisfactory basis of classification, and recourse must be had to others of a more constant nature. Odhner has already (1905) denoted the chief of these, namely, the structure of the copulatory organs, the structure of the head and the disposition of the yolk glands.

Apart from the situation of the genital glands and the configuration of the uterus, the species included in the genus *Prosorhynchus* appear to form a homogeneous group. The same, however, cannot be said with regard to the remaining species of Gasterostomes, included by Odhner under the genus *Gasterostomum* (=*Bucephalus*).

They all agree in having the yolk glands arranged in two distinct groups, which are usually marginal in position, and, so far as is known, the structure of the copulatory organs does not vary very much from the type found in *Bucephalus polymorphus* (=*Gasterostomum fimbriatum*). It is in the structure of the anterior end that we meet with the most pronounced features of difference. Three main types may be recognised. (1) The anterior end may be provided with a simple sucker as in *Gasterostomum gracilescens* and *G. tergestinum*. This sucker closely resembles the ventral sucker of the prosostomate distomes, and is regarded by Odhner as the primitive type of head structure in the Gasterostomes. (2) From the sucker muscular prolongations may grow out in the form of tentacles or fimbriae as in *G. fimbriatum* and *G. minimum* Stossich. (3) The sucker may degenerate in musculature, become very shallow and be surmounted by a contractile fan-shaped hood as in *G. triglae* and *G. viperae*. It is apparent that some generic separation of these three groups is desirable, and it is only on the structure of the anterior end that this is practicable. Each of these three groups has already, in earlier literature, been regarded as of generic or at least subgeneric importance. The synonymy is slightly complicated.

The monotypical genus *Gasterostomum* was founded on *G. fimbriatum*, and as this has been shown to be the adult of the earlier known *Bucephalus polymorphus* the name *Gasterostomum fimbriatum* must be regarded as *nomen nudum* and the genus *Gasterostomum* as a synonym of *Bucephalus*.

In 1855 Diesing erected the sub-genus *Bucephalopsis* for the larval form *B. haimeanus*, and this has been shown to be the larva of *Gasterostomum gracilescens* (Rud.). This species is undoubtedly the type of a distinct genus, and on that account I propose to raise the sub-genus *Bucephalopsis* to generic rank with *B. gracilescens* (Rud., 1819) as type.

A complication enters here, however, for in 1858 Diesing erected the genus *Rhipidocotyle* for the reception of the two species *G. gracilescens* and *G. minimum* Wagener (*nec.* Stossich) without designating the type. Stiles & Hassall (1908) have tentatively taken *G. gracilescens* as the type of this genus, but, as I shall show, *G. minimum* Wagener is undoubtedly the real type of this genus.

I am, unfortunately, not personally familiar with Wagener's original specimens, nor have I had an opportunity of examining any Gasterostomes from the type host, *Trigla microlepidota*, but a careful study of Wagener's original figure (1852) has suggested to me that *G. minimum* Wagener is identified with *G. triglae* van Beneden, 1870, and with the form which I have described under that name (1909). The most characteristic feature of this species is the highly contractile fan-shaped structure which surmounts the anterior sucker. To both Wagener and van Beneden this structure must have appeared in a very contracted condition and so have escaped observation. Diesing, however, must have been familiar with it and have been influenced by it in his choice of a generic name, hence the highly descriptive combination *Rhipidocotyle* (ῥῖπίς, ῥῖπῖδος=a fan, κοτύλη=a cup). No more appropriate term could have been invented. At the same time it is remarkable that Diesing should have included in the same genus *G. gracilescens*, which possesses no such fan-shaped structure.

There is nothing in the remaining anatomy of either of these species which to my mind bears the slightest resemblance to a fan, and on that account I am convinced that it was the fan-shaped cephalic hood which Diesing regarded as the distinctive feature of this genus. It will thus be necessary to revive the old generic term which Odhner (1905, p. 296, note 3) somewhat cavalierly consigned to the "lumber room of useless names."

As Gasterostomum has become a *nomen nudum* the family name Gasterostomidae must be replaced by Bucephalidae, and this family will now include the genera *Bucephalus* Baer, 1827, *Bucephalopsis* (Diesing, 1855), *Rhipidocotyle* Diesing, 1858, and *Prosorhynchus* Odhner, 1905. As Odhner has already suggested, a further separation of these genera appears advisable. I propose to separate them into two sub-families, *Bucephalinae*, n. subfam. and *Prosorhynchinae*, n. subfam.

The definitions of these sub-families are identical with the definitions given by Odhner (1905, pp. 296–7) for the genera *Gasterostomum* and

Prosorhynchus respectively. Bucephalinae includes the genera *Bucephalus*, as type, *Bucephalopsis* and *Rhipidocotyle*.

The definition of these three genera may be summed up briefly as follows :—

Bucephalus Baer, 1827.

Bucephalinae in which the anterior end is provided with a muscular sucker around which are a number of muscular retractile tentacles or fimbriae. Type : *B. polymorphus* Baer, 1827 (=*Gasterostomum fimbriatum* v. Siebold, 1848) *B. minimus* (Stossich) (*Gasterostomum minimum* Stossich, 1887, *nec.* Wagener, 1852) may also be included in this genus.

Gasterostomum gorgon Linton, 1905, may be provisionally included here, but will probably require to be regarded as the type of a distinct genus. The "Gasterostomum sp." depicted by Linton (1910, Fig. 225) from *Sphyraena barracuda* may possibly belong to this genus.

Bucephalopsis Diesing, 1855.

Bucephalinae in which the anterior end is provided with a simple globular muscular sucker. Type : *B. gracilescens* (Rud., 1819). *G. tergestinum* Stossich, 1883, should be included here, and probably a number of American forms.

Rhipidocotyle Diesing, 1858.

Bucephalinae in which the anterior end is provided with a feebly developed, shallow sucker surmounted by a fan-shaped hood. When this is contracted the anterior end appears square. Type : *R. minima* (Wagener, 1852), Nicoll, 1914 (=*Gasterostomum triglae* van Ben., 1870, Nicoll, 1909), includes also *R. viperae* (van Ben., 1870), Nicoll, 1914, and probably a number of species from American fishes (Linton, 1910, Figs. 217, 222, 223).

Family **BUCEPHALIDAE.**

Sub-Family Bucephalinae.

Genus BUCEPHALOPSIS (Diesing).

Bucephalopsis gracilescens (Rud.).

Lebour, 1908, pp. 18–21.

This common parasite of *Lophius piscatorius* was found in four out of five specimens of that fish. It occurred in the intestine and pyloric caeca, usually in large numbers.

Genus BUCEPHALUS Baer.

Bucephalus minimus (Stossich).

=*Gasterostomum minimum* Stossich, 1887, p. 96.

About two dozen specimens of a small Gasterostome were found in the intestine of *Labrax lupus*. They correspond in most respects with Stossich's description of *Gasterostomum minimum* from the same host, but the position of the testes and the extent of the uterus are different.

It is a small plump form reaching a length of a little over 1 mm. The outline is oval and the maximum breadth is about half the length. The anterior sucker is terminal and is surrounded by a circle of six highly contractile tentacles. When extended these tentacles may be long and almost filiform. When completely retracted they are almost impossible to discern. In a semi-contracted state they appear as small, fleshy, knob-like protuberances.

The ovary lies on the right side of the pharynx, which is situated about the middle of the body. The testes lie directly behind the pharynx. They are oblique and overlap each other considerably. The uterus fills up a large part of the body, extending forward as far as the level of the anterior sucker. The ova measure ·022–·024 × ·013–·015 mm.

Genus RHIPIDOCOTYLE Diesing.

Rhipidocotyle minima (Wagener).

=*Gasterotomum triglae* (van Ben.), Nicoll.

This species was met with in the intestine of the gurnards, *Trigla pini*, *T. gurnardus*, and *T. hirundo*. In the last-named it occurred also in the pyloric caeca. The parasite was not found in the half-dozen specimens of *Trigla lyra* which were examined.

The only note which may be added to my previous description (Nicoll, 1909, pp. 23–4) is that in this species the excretory vesicle is of great length and extends a considerable distance in front of the ventral sucker. It even reaches further forward than the fundus of the stomach.

Several specimens of what appeared to be this species were met with in the intestine of *Trachinus vipera*. They agree in every particular except that the pharynx is situated further back. It is constantly behind the middle of the body, and may even be found as far back as the anterior end of the cirrus-pouch. Its relation to the other organs is consequently very variable. Sometimes it is on the level of the anterior testis. The only other noticeable feature is that the anterior sucker and the pharynx are less unequal in diameter than is the case in typical examples of *G. triglae.* In consequence of the great variation which undoubtedly occurs it is not thought advisable to regard this as a distinct species.

Rhipidocotyle viperae (van Ben.) (Fig. 4).

I am identifying as this species a few Gasterostomes which were obtained from the intestine of *Trachinus draco.* It is a form which resembles *G. triglae* in general appearance, but which differs from it in having the genital glands arranged differently and in having a long and slender cirrus-pouch which extends forward to near the middle of the body.

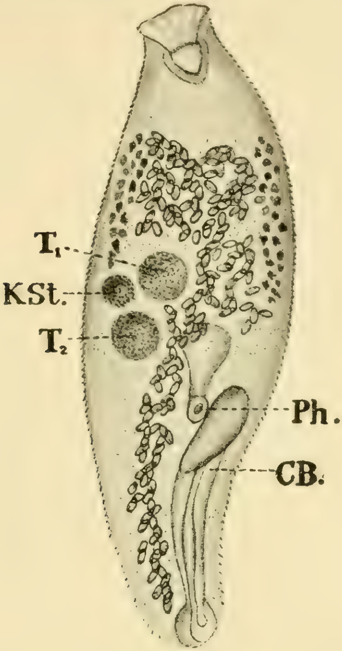

FIG. 4.—*Rhipidocotyle viperae.* Ventral view ×85. C.B. Cirrus-pouch; K.St. Ovary; Ph. Pharynx; T. Testes. *G. Roberts del.*

The length of mature specimens is ·7–1·2 mm., and the maximum breadth in the middle of the body is about ·4 mm. The anterior end is square-cut and the posterior end pointed. The whole surface of the body is beset with minute spines.

At the anterior end there is a shallow sucker measuring, in the largest specimen, ·13 mm. in diameter. Its musculature is very feebly developed. Surmounting the sucker is a five-rayed fan-shaped structure, closely resembling the corresponding structure in *R. minimum*. This is not represented in van Beneden's figure.

The pharynx (ventral sucker) is situated ·8 mm. from the anterior end of the body. Its diameter is about ·055 mm. The short intestinal sac is obscured by the uterus.

The genital glands lie close together on the right side a short distance in front of the mouth. The ovary is about ·6 mm. from the anterior end of the body and lies close up against the side. It is globular and has a diameter of ·1 mm. The testes are contiguous to it and to each other, the first testis lying alongside and a little in front of the ovary, the second testis lying directly behind the ovary and first testis. Both testes are globular and somewhat larger than the ovary, having a diameter of ·12 mm. In van Beneden's figure the testes are separated by the pharynx, and what might be regarded as the ovary lies in front. It is possible, however, that that problematic structure really represents the intestinal sac, in which case the ovary is not shown.

The yolk glands extend along the margins of the body from the level of the ovary to a point about ·25 mm. from the anterior end. The uterus fills up the space between the yolk glands and passes backwards between the testes and the pharynx. The ova measure ·036–·037 × ·018–·021 mm.

The cirrus-pouch is a long slender structure which extends forwards to a short distance in front of the mouth. There is a fairly large simple vesicula seminalis, a long pars prostatica and a short ductus.

Sub-Family PROSORHYNCHINAE.

Genus PROSORHYNCHUS Odhner.

Prosorhynchus squamatus Odhner.

Odhner, 1905, pp. 297–304; Lebour, 1908, pp. 21–3.

This was found on two occasions in the duodenum of *Cottus bubalis*, the first time in large numbers, the second time as a single specimen.

Prosorhynchus aculeatus Odhner.

Nicoll, 1910, pp. 350–2.

This common parasite of the conger was found in three out of four specimens of the fish.

Prosorhynchus crucibulum (Molin).

Nicoll, 1910, pp. 352–4.

This was found in association with *P. aculeatus* and quite as frequently.

Prosorhynchus triglae sp. inq. (Fig. 5).

Single specimens of this species were found on two occasions, once in the intestine and once in the stomach of *Trigla gurnardus*. Both specimens were quite immature, so that it is impossible to give a complete description of the species, which appears to be hitherto unrecorded. It measures 2·2–2·4 mm. in length and ·75 mm. in maximum breadth. At the anterior end there is a wedge-shaped rostellum resembling that in *P. crucibulum* (diameter ·3 mm.). The small ventral sucker (pharynx) is situated nearly in the middle of the body (diameter ·1 mm.).

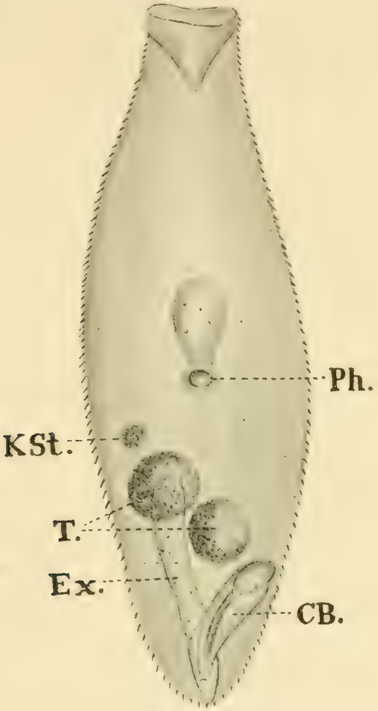

FIG. 5.—*Prosorhynchus triglae*. Ventral view ×40. C.B. Cirrus-pouch; Ex. Excretory vesicle; K.St. Ovary; Ph. Pharynx; T. Testes. *G. Roberts del.*

The intestinal sac extends forwards and is not of very large size. The excretory vesicle extends about one-half or two-thirds the distance between the posterior end of the body and the pharynx.

The cirrus-pouch is about half the length of the excretory vesicle. The testes are fairly large, close together and nearly tandem. The posterior (left) testis is contiguous with the cirrus-pouch in one and displaced to the left in the other.

The small ovary lies immediately in front of the anterior testis on the right side. The yolk glands were not distinct.

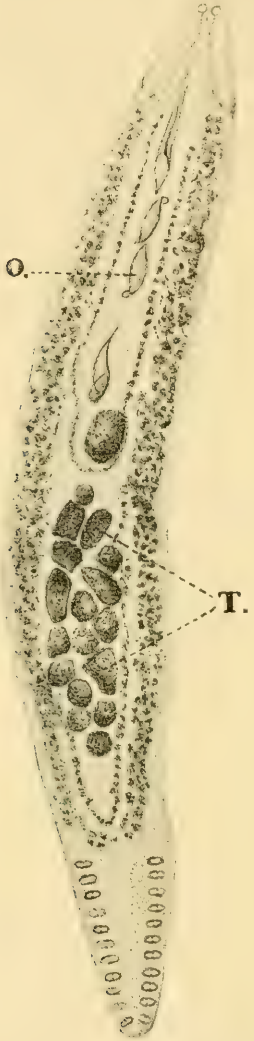

FIG. 6.—*Microcotyle draconis.* Ventral view × 25 (Specimen from Aberdeen). O. Ova; T. Testes. *M. Rhodes del.*

MONOGENEA.

The number of ectotrematodes collected was not very large, and they were all, with perhaps one exception, common and well-known species. *Axine belones*, *Octobothrium merlangi* and *Octocotyle scombri* were found on the gills of *Belone vulgaris*, *Gadus merlangus* and *Scomber scombrus* respectively. *Pseudocotyle squatinae* was found on the skin of *Rhina squatina*, and *Calicotyle Kroyeri* was met with in the cloaca of the three rays, *Raja circularis*, *R. maculata* and *R. clavata*. A species of *Microcotyle* was obtained from the gills of *Trachinus draco*. Two specimens only were present, and they were not quite mature. Their posterior end was provided with seven suckers on each side. Some similar specimens were collected from the same host at Aberdeen (Fig. 6). They were larger and apparently fully mature. In them the posterior end had eleven pairs of suckers. I am unable to decide whether these two forms are identical or not, and whether both are identical with the *Microcotyle draconis* obtained by Briot (1904) from the same host. As Briot's work is not accessible to me I am unable to make any comparison of these forms. The probability is that my specimens are identical with those of Briot.

Descriptions of *Calicotyle Kroyeri* and *Octobothrium merlangi* are to be found by Lebour (1908, pp. 49 and 50). A description of *Axine belones* will be found by Scott (1911, p. 69).

LIST OF FISHES EXAMINED AT PLYMOUTH, WITH THE TREMATODE PARASITES COLLECTED FROM THEM.

1. *Labrax lupus.*	
Cainocreadium labracis.	Intestine.
Acanthochasmus imbutiformis.	Intestine.
Bucephalus minimus.	Intestine.
2. *Serranus cabrilla.*	
Helicometra pulchella.	Intestine.
Lecithaster gibbosus.	Rectum.
3. *Mullus barbatus.*	
Derogenes varicus.	Stomach.
4. *Sparus centrodontus.*	
Steringotrema pagelli.	Intestine.
Zoonogenus vividus.	Rectum.
Derogenes varicus.	Stomach.
Hemiurus communis.	Stomach.
5. *Trachurus trachurus.*	
Tergestia laticollis.	Rectum.
Derogenes varicus.	Stomach.
Lecithaster gibbosus.	Intestine.
Hemiurus communis.	Intestine.

6. *Capros aper.*	
Pharyngora bacillaris.	Intestine.
Derogenes varicus.	Stomach.
Hemiurus communis.	Stomach.
Hemiurus ocreatus.	Stomach.
7. *Scomber scombrus.*	
Pharyngora bacillaris.	Intestine.
Hemiurus ocreatus.	Stomach.
Lecithocladium excisum.	Stomach.
Octocotyle scombri.	Gills.
8. *Zeus faber.*	
Stephanochasmus cesticillus.	Intestine.
Zoogonoides viviparus.	Rectum.
Derogenes varicus.	Stomach.
Lecithaster gibbosus.	Rectum.
Synaptobothrium caudiporum.	Stomach.
9. *Trachinus draco.*	
Derogenoides ovacutus.	Stomach.
Derogenes varicus.	Stomach.
Rhipidocotyle viperae.	Intestine.
Microcotyle draconis (?).	Gills.
10. *Trachinus vipera.*	
Derogenes varicus.	Intestine.
Lecithaster gibbosus.	Intestine.
Rhipidocotyle minimum.	Intestine.
11. *Lophius piscatorius.*	
Derogenes varicus.	Œsophagus.
Hemiurus communis.	Stomach.
Lecithochirium rufoviride.	Stomach.
Synaptobothrium caudiporum.	Stomach.
Bucephalopsis gracilescens.	Intestine and coeca.
12. *Cottus bubalis.*	
Podocotyle atomon.	Intestine.
Derogenes varicus.	Stomach.
Hemiurus communis.	Stomach and intestine
Prosorhynchus squamatus.	Duodenum.
13. *Agonus cataphractus.*	
Derogenes varicus.	Caeca and intestine.

14.	*Callionymus lyra.*	
	Lebouria varia.	Intestine.
	Zoogonoides viviparus.	Rectum.
	Derogenes varicus.	Mouth.
15.	*Trigla pini.*	
	Helicometra pulchella.	Caeca.
	Derogenes varicus.	Stomach.
	Lecithaster gibbosus.	Stomach.
	Hemiurus communis.	Stomach.
	Rhipidocotyle minima.	Intestine.
	Phyllocotyle gurnardi.	Gills.
16.	*Trigla gurnardus.*	
	Derogenes varicus.	Stomach.
	Hemiurus communis.	Stomach.
	Rhipidocotyle minima.	Intestine.
	Prosorhynchus triglae.	Stomach and intestine.
17.	*Trigla hirundo.*	
	Derogenes varicus.	Stomach and mouth.
	Synaptobothrium caudiporum.	Stomach and mouth.
	Rhopidocotyle minima.	Intestine and caeca.
18.	*Cyclopterus lumpus.*	
	Pharyngora bacillaris.	Intestine and caeca.
	Derogenes varicus.	Stomach.
19.	*Cyclogaster montagui.*	
	Podocotyle atomon.	Intestine.
20.	*Gobius ruthensparri.*	
	Podocotyle atomon.	Intestine.
21.	*Gobius paganellus.*	
	Helicometra pulchella.	Intestine and stomach.
	Hemiurus communis.	Stomach.
22.	*Blennius gattorugine.*	
	Helicometra pulchella.	Intestine and stomach.
	Zoogonoides viviparus.	Rectum and intestine.
	Monorchis monorchis.	Stomach.
23.	*Blennius ocellaris.*	
	Steringotrema divergens.	Duodenum.
	Zoogonoides viviparus.	Rectum.
	Derogenes varicus.	Mouth.

24. *Blennius pholis.*		
	Peracreadium genu.	Intestine.
	Helicometra pulchella.	Intestine.
	Lecithochirium rufoviride (larva).	Encysted in viscera.
	Synaptobothrium caudiporum (larva).	Encysted in viscera.
25. *Centronotus gunnellus.*		
	Podocotyle atomon.	Intestine.
26. *Mugil chelo.*		
	Haploporus benedeni.	Intestine.
	Saccocoelium obesum.	Intestine.
27. *Atherina presbyter.*		
	(Podocotyle) atherinae.	Intestine.
	Bacciger bacciger.	Stomach.
28. *Gastraea spinachia.*		
	Podocotyle atomon.	Intestine.
	Podocotyle reflexa.	Intestine.
29. *Lepadogaster gouanii.*		
	Helicometra pulchella.	Intestine.
	Hemipera ovocaudata.	Stomach.
	Hemiurus communis.	Rectum.
30. *Labrus berggylta.*		
	Peracreadium genu.	Rectum.
	Peracreadium commune.	Intestine.
	Lebouria alacris.	Intestine.
	Helicometra pulchella.	Intestine.
	Lepidauchen stenostoma.	Intestine.
	Synaptobothrium caudiporum (larva).	Encysted in intestinal wall.
31. *Labrus mixtus.*		
	Helicometra pulchella.	Intestine.
32. *Crenilabrus melops.*		
	Peracreadium commune.	Intestine.
	Lebouria alacris.	Intestine.
	Synaptobothrium caudiporum (larva).	Encysted in intestinal wall.

33. *Centrolabrus rupestris.*	
Lebouria alacris.	Intestine.
Helicometra pulchella.	Intestine.
34. *Centrolabrus exoletus.*	
Lebouria alacris.	Intestine.
35. *Gadus luscus.*	
Stephanochasmus caducus.	Intestine and coeca.
Derogenes varicus.	Stomach.
Hemiurus communis.	Stomach.
36. *Gadus minutus.*	
Stephanochasmus caducus.	Caeca.
Derogenes varicus.	Stomach.
Hemiurus communis.	Stomach.
37. *Gadus merlangus.*	
Podocotyle atomon.	Caeca.
Stephanochasmus pristis.	Duodenum.
Pharyngora bacillaris.	Caeca.
Derogenes varicus.	Stomach.
Lecithaster gibbosus.	Intestine.
Hemiurus communis.	Stomach.
Hemiurus ocreatus.	Stomach.
Octobothrium merlangi.	Gills.
38. *Gadus pollachius.*	
Lepipapedon rachion.	Intestine.
Derogenes varicus.	Stomach.
Hemiurus communis.	Stomach.
Hemiurus ocreatus.	Stomach.
39. *Molva molva.*	
Derogenes varicus.	Stomach.
Hemiurus communis.	Stomach.
40. *Onos mustela.*	
Podocotyle reflexa.	Intestine, caeca and stomach.
41. *Onos tricirratus.*	
Derogenes varicus.	Stomach.
42. *Ammodytes lanceolatus.*	
Hemiurus communis.	Stomach.

43. *Bothus maximus.*		
	Derogenes varicus.	Stomach.
44. *Pleuronectes flesus.*		
	Podocotyle atomon.	Intestine.
	Derogenes varicus.	Intestine.
45. *Pleuronectes limanda.*		
	Steringotrema cluthense.	Duodenum.
	Zoogonoides viviparus.	Rectum and intestine.
	Derogenes varicus.	Stomach and intestine.
46. *Pleuronectes microcephalus.*		
	Steringotrema cluthense.	Duodenum.
	Zoogonoides viviparus.	Rectum and intestine.
47. *Pleuronectes platessa.*		
	Zoogonoides viviparus.	Rectum.
48. *Zeugopterus punctatus.*		
	Helicometra pulchella.	Intestine.
	Hemiurus communis.	Stomach.
49. *Zeugopterus norvegicus.*		
	Podocotyle atomon.	Rectum.
	Lecithaster gibbosus.	Intestine.
50. *Solea vulgaris.*		
	Zoogonoides viviparus.	Intestine.
	Derogenes varicus.	Stomach and intestine.
51. *Solea variegata.*		
	Zoogonoides viviparus.	Rectum and intestine.
52. *Salmo trutta.*		
	Bunodera nodulosa.	Intestine.
	Derogenes varicus.	Stomach.
53. *Clupea pilchardus.*		
	Hemiurus ocreatus.	Stomach.
54. *Belone vulgaris.*		
	Axine belones.	Gills.
55. *Anguilla vulgaris.*		
	Podocotyle atomon.	Intestine.
	Helicometra pulchella.	Intestine.
	Lecithochirium rufoviride.	Stomach.

56. *Conger conger.*	
Helicometra pulchella.	Intestine.
Derogenes varicus.	Stomach.
Lecithochirium rufoviride.	Stomach.
Prosorhynchus aculeatus.	Intestine.
Prosorhynchus crucibulum.	Intestine.
57. *Syngnathus acus.*	
Podocotyle syngnathi.	Intestine.
58. *Nerophis aequoreus.*	
Podocotyle atomon.	Intestine.
Podocotyle syngnathi.	Intestine.
Hemiurus communis.	Intestine.
59. *Siphonostoma typhle.*	
Podocotyle syngnathi.	Intestine.
Acanthochasmus imbutiformis (larva).	Encysted in gills.
60. *Raja circularis.*	
Calicotyle kroyeri.	Rectum.
61. *Raja maculata.*	
Calicotyle kroyeri.	Cloaca.
62. *Raja clavata.*	
Calicotyle kroyeri.	Rectum.
63. *Mustelus vulgaris.*	
Ptychogonimus megastomus.	Stomach.
64. *Rhina squatina.*	
Pseudocotyle squatinae.	Skin.

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On a Hermaphrodite Specimen of Amphioxus with Notes on Experiments in Rearing Amphioxus.

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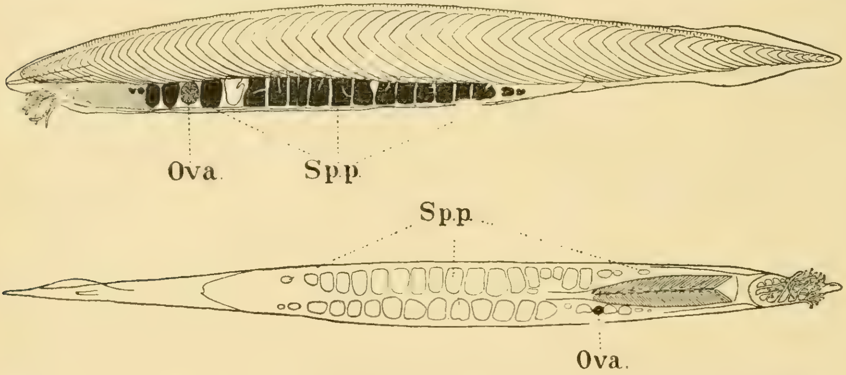
With Figures 1–5 in the Text.

A specimen of *Amphioxus lanceolatus* containing both sperm and eggs was observed in June this year whilst experiments were being conducted on obtaining the larvæ of this animal. The individual in which this phenomenon was observed is predominantly male, and was actually seen to discharge a large amount of living spermatozoa, but of the forty-three large gonadial pouches present in the animal one only contains eggs and the remainder sperm. On the right side of the body are twenty-two well-developed gonadial pouches, two of which became nearly empty by the discharging of spermatozoa; the remainder were full of sperm when the animal was preserved. On the left are nineteen pouches full of sperm and one is nearly empty, but one pouch, the fifth from the anterior end,



Figs. 1 and 2.—*Views of a hermaphrodite specimen of Amphioxus from the left side and the ventral region respectively. Ova are present in one gonadial pouch only, while all the remaining pouches contain sperm. (Drawn from the whole animal stained in Delafield's hæmatoxylin and cleared in cedar-wood oil, × about 2½.) Sp.p. Gonadial pouches full of sperm.

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* I am indebted to Mrs. Orton for the drawings for Figs. 1 and 2, and for assistance with that for Fig. 3; and also to Mr. E. Ford for the lettering of the Figures.

is full of eggs (see Figs. 1 and 2). The relation of the pouches on the right side to those on the left appears (as may be seen from Fig. 2) to be normal. The smaller pouches have been reduced somewhat in size from the loss of sperm referred to above. A few other rudimentary microscopic pouches are present in the posterior region of the body.

FIG. 3.

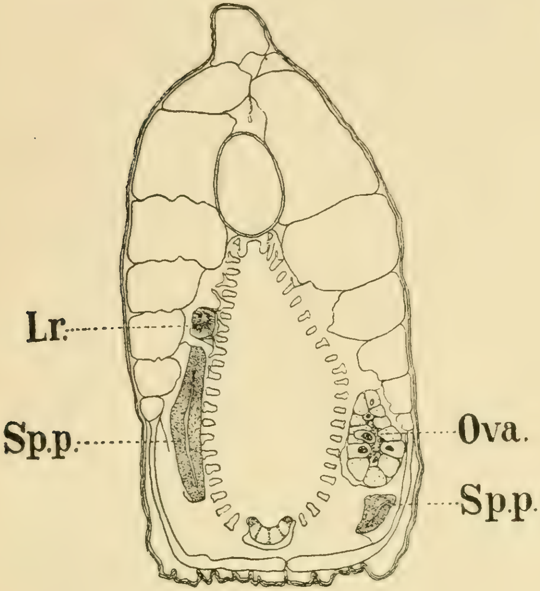
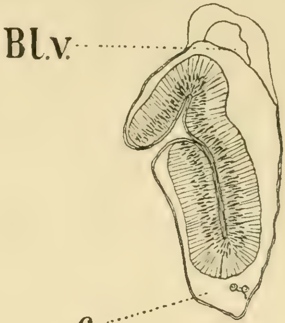


FIG. 4.



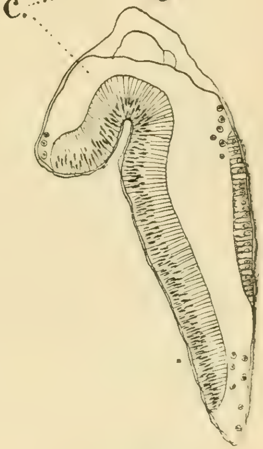


FIG. 5.

FIG. 3.—Transverse section through a hermaphrodite specimen of *Amphioxus lanceolatus* showing gonadial pouches with sperm or ova and the anterior end of the abnormal liver. Ova are present in one pouch only.

Sp.p. Gonadial pouches filled with sperm.
Lr. Anterior prolongation of liver.

FIG. 4.—Transverse section of liver at the level of the sixth right gonadial pouch (semi-diagrammatic).

Bl.v. Blood vessel in cœlomic space surrounding the liver.
C. Cavity of liver.

FIG. 5.—Transverse section of liver at the level of the thirteenth right gonadial pouch (semi-diagrammatic).

In transverse sections the gonadial pouch bearing eggs is seen to have the primary and secondary cavities normally shown by the female gonads (see Fig. 3), and the invaginated form of the pouch described by Legros * is also well shown in some sections (but is not shown in Fig. 3). Thus the structure of this pouch is of the normal female plan.

The transverse section shown in Fig. 3 shows also an abnormal feature of much interest. On the right side (the reader's left) in the dorsal region of the atrial cavity is a structure resembling a groove opening on to the outer region of the atrium but enveloped by an extremely thin membrane on its pharyngeal side so as to enclose a narrow cavity. This structure arises at about the level of the second right gonadial pouch, and is continued backwards and gradually enlarges to about the level of the seventh right gonad, the groove gradually opening out to this point (see Figs. 4 and 5).

An examination of a series of sections of the whole of the gonadial region of the animal shows, however, that this apparent groove is really a forward continuation of the liver. At about the level of the seventh right gonad the structure assumes the more definitely tubular form of a liver by the divergence of the thin membrane from the groove-like portion which also becomes straightened out (see Fig. 4). The liver retains practically the same characters throughout its length, having its right wall composed of columnar epithelium tucked inwards along the whole of the middle of its length, as shown in Fig. 4, but having the left wall almost entirely membranous (see Fig. 5). At the junction of the liver with the intestine a columnar epithelium is developed on the whole of its wall. Thus the digestive gland in this specimen is highly abnormal; its condition is very probably correlated with the abnormal state of the sexual organs.

A careful examination has been made of the tissues for parasites, but nothing of sufficient importance has so far been detected to confirm the suggestion that the hermaphroditism may be due to the influence of parasites. A fair number of small nucleated spherical bodies are present in the cavity of the liver, and bodies are present in some of the abnormal intuckings of the intestinal wall which may be parasites, but the methods of staining employed up to the present have certainly not disclosed such an extensive invasion of foreign bodies in the tissues as perhaps one might expect to find in an animal whose sex is abnormally changed by an infection of parasites.

The occurrence of hermaphrodite specimens of Amphioxus has been recorded previously on only two occasions so far as I know. In 1876

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* M. Legros, "Sur la Morphologie des Glandes sexuelles de *l'Amphioxus lanceolatus*," *Comptes-Rendus du Troisième Congrès Internationale de Zoologie*, Leyden, 1895.

Langerhans stated* that he had detected the tails of spermatozoa among young ovarian ova of Amphioxus, and recently in 1912 Goodrich† described a more definitely hermaphrodite specimen from Naples which closely resembles the one obtained here at Plymouth in having only one gonadial pouch producing eggs—the ninth on the left side—but with the remaining forty-nine pouches full of spermatozoa.

Goodrich has already pointed out that hermaphroditism would appear to be a rare phenomenon in Amphioxus since large numbers have been and are being carefully examined. It occurred to me, however, that possibly the hermaphroditism might be more common in Amphioxus than would appear to be in the case, for after the discharge of the gonadial products the gonadial pouches contract into a very small compass, and presumably a fresh set of gonadial products are formed subsequently. Thus it would be possible for a given individual Amphioxus to have two different sets of gonads, first of one sex and afterwards of the other. Moreover, such a change would probably not be detected unless a number of Amphioxus were reared in captivity from the young to the adult stage. In this way the chance observations referred to above of two males each with one egg-bearing pouch may possibly indicate an unsuspected change of sex in the life-history of the animal. If such a change were to occur the occurrence of egg-bearing pouches in a male might be an expression of a precocious development of female characteristics. A further indication that a change of sex would be in the direction of male to female lies in the fact that the hermaphrodite forms are both of medium size: Goodrich's specimen being about 4·7 cms. long, and mine measured 4·4 cms. in cedar-wood oil. It is very probable that the animals become mature for the first time at about this size.

On the view, however, that there is a sex-change in Amphioxus one would expect all the young individuals to be of the same sex, but the researches of three different investigators, namely, Legros (l.c.), Neidert and Leiber,‡ and Zarnik,§ show that both male and female gonads have been traced in very small individuals. Hence it seems certain that there cannot be any total sex-change in Amphioxus; but there still remains the possible, but hardly probable, occurrence of a sex-change in only some individuals.

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* P. Langerhans, *Archiv f. Mikr. Anat.*, Bd. XII, 1876, p. 326.

† E. S. Goodrich, " A Case of Hermaphroditism in Amphioxus," *Anat. Anz.*, 42 Bd., 1912.

‡ L. Neidert u. A. Leiber, " Über Bau und Entwicklung der Weiblichen Geschlechtsorgane des Amphioxus," *Zool. Jahrb.*, Bd. XVIII, 1903.

§ B. Zarnik, " Uber die Geschlechtsorgane von Amphioxus," *Zool. Jahrb. Abt. Anat.*, Bd. XXI, 1905.

It would therefore appear that these occasional hermaphrodites in Amphioxus must remain for the present unexplained like the similar and not uncommon phenomena among many fishes.* The abnormality of the liver and the intestine as well as that of the sexual organs points, however, to some deep-seated disorganisation in the economy of the animal, the cause of which I have not been able to detect.

NOTES ON EXPERIMENTS ON REARING AMPHIOXUS.

A few experiments were carried out this summer with the object of obtaining the larvæ of Amphioxus. As two of the experiments were successful, and as the larvæ of Amphioxus have apparently not been obtained at Plymouth before, these notes may be useful to future workers.

Larvæ of Amphioxus were obtained on two occasions on June 10th and June 15th by merely isolating a number of adult males and females in a small glass bowl. The adult specimens were examined under a microscope when brought in and a few mature males put into bowls in company with mature females. It is possible to distinguish the adult sexes in the living condition, and indeed the hermaphrodite specimen described in the preceding pages was identified as such while alive. It was found advantageous to feed the Amphioxus on a fairly thick culture of the diatom Nitzschia which the animals ingest in great numbers. By gorging themselves with this food the Amphioxus are probably able to extrude eggs or sperm more easily than when they are empty.

Spawning apparently occurs usually overnight, as gastrulæ were obtained in both experiments about midday. It is not easy to calculate the time of spawning from the known age of gastrulæ reared at Naples, since the rate of development of larvæ at Plymouth is undoubtedly slower than at Naples, as was shown by subsequent observations. Since, however, gastrulæ were obtained about noon it seems likely that spawning had occurred sometime about midnight. In this respect it is interesting to observe that the hermaphrodite specimen just described was observed to spawn during the day,* but it is probable that this spawning may have been abnormal and induced by the animal having jumped out of a bowl and remained dry on the bench for a little while.

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* With regard to the occasional hermaphrodites among fishes it may be remarked that it is highly important to know the size and also the age of specimens—which are usually omitted from descriptions—if the data are to be useful for investigating the life-history of the fish.

In the second experiment in which fertilised eggs were obtained the embryos had reached the blastula and gastrula stages by 1.0 p.m. At 6.0 p.m. on the same day, June 15th, the gastrulæ began to elongate, and by 9.0 p.m. two to three mesoblastic somites were developed and the larvæ were beginning to find their way out of their fertilization membranes. On June 16th at 2.5 p.m. the larvæ had developed six to eight pairs of mesoblastic somites and the head cavities. On the 17th at 2.30 p.m. the larvæ reached a stage similar to Hatschek's Fig. 64,† in which the club-shaped gland is present. At Naples this stage is reached at an age of about 36 hours, whereas the Plymouth embryos only reached the corresponding stage at an age of about 60 hours. During subsequent days the larvæ increased a little in length and were observed to be feeding, but even on the 30th of the month when the larvæ were a fortnight old only the first few gill-slits had appeared, and shortly afterwards it was unfortunately necessary to abandon the larvæ.

In preserving batches of larvæ it was observed that the individual of the latter stages became stuck to the bottom of the vessel in the head region. This circumstance seems to point to the possibility of the club-shaped gland pouring out some secretion to the exterior, since this gland is the only organ developed at this stage ; and since moreover, according to Willey,‡ "this stage of the larval development appears to be of the nature of a *resting phase*, during which the larvæ accumulates energy for future growth," it may be that a secretion of the club-shaped gland serves to attach the larva temporarily to objects during this resting stage, or to suspend the larva in the water (see Willey, l.c., p. 130). These are, however, merely suggestions, which nevertheless might well repay further investigation by naturalists who may have the opportunity of doing so.

It may further be noted that the opening of the club-shaped gland is on the left side ; hence if a secretion of this gland is used for attaching the larva temporarily to objects, then the larva would be able to feed only from the right side of the body. As is well known, the first formed gill-slits do develop on the right side of the body and afterwards shift over to the left after the disappearance of the club-shaped gland. It is therefore possible that the larval asymmetry of Amphioxus may be correlated with the function of the club-shaped gland, and if the suggestion here made that this gland may secrete a substance for attaching the larva temporarily to objects is found to be a fact, a simple explanation similar to that put forward by Korscheldt and Heider is offered of the curious asymmetry in the early larval development of this interesting animal.

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* The actual time was not recorded, but it was some time between 11 a.m. and 4.30 p.m.

† B. Hatschek, "Entwicklung des Amphioxus," *Arb. Zool. Inst. Wien.*, 1881, Vol. IV.

‡ A. Willey, *Amphioxus and the Ancestry of the Vertebrates*, 1894, p. 172.

SUMMARY.

A hermaphrodite specimen of Amphioxus has been taken at Plymouth having one gonadial pouch filled with ova and the remaining pouches filled with sperm. This specimen closely resembles a similar one taken by Goodrich at Naples.

The liver and intestine of the Plymouth specimen are abnormal, but no parasites have been identified in the tissues to account for these abnormalities.

It is, moreover, improbable that there is any normal sex-change in Amphioxus, since three independent investigators have found very small specimens of both sexes, therefore no satisfactory explanation can be given of the occurrence of hermaphroditism in the specimen.

Amphioxus have been found to spawn in June, and larvæ have been obtained from the captive specimens.

It is suggested that the club-shaped gland may secrete a substance for attaching the larva of Amphioxus to objects, and that this function may be correlated with the asymmetry shown in the early development of the Amphioxus larva.

ABSTRACTS OF MEMOIRS

RECORDING WORK DONE AT THE PLYMOUTH LABORATORY

The Influence of the Position of the Cut upon Regeneration in *Gunda ulvæ*. By Dorothy Jordan Lloyd, B.Sc. (*Proc. Roy. Soc.*, B, Vol. XXVII, 1914.)

In 1889 Hallez published a paper in the *Comptes Rendus* in which he stated that any fragment from a Triclad could regenerate completely, while from a Polyclad, only those fragments could do so which contained a portion of the central nervous system. The paper quoted above on the regeneration of *Gunda ulvæ*, a marine Triclad common at Plymouth, shows that this generalization is not of universal application, since in *G. ulvæ* regeneration of the anterior end is found to be dependent, as in Polyclad, on the presence of the central nervous system.

Posterior, anterior, and lateral regeneration are considered separately. Posterior regeneration, i.e. regeneration of any structure lying behind the brain, is found to take place equally well in the presence or absence of the cerebral ganglia. Lateral regeneration, in order to be complete, requires the presence of one intact ganglion. If only part of a ganglion is present, heads regenerate but are abnormal. If both ganglia are absent lateral regeneration only takes place behind the level of the ganglia. Anterior regeneration never occurs except in the presence of at least two-thirds of both ganglia.

The paper also records the formation of heteromorphic heads from short head-pieces of *G. ulvæ* in which the cut has passed transversely across both ganglia.

D. J. L.

The Influence of Osmotic Pressure upon the Regeneration of *Gunda ulvæ*. By Dorothy Jordan Lloyd, B.Sc. (*Proc. Roy. Soc.*, B, Vol. XXVII, 1914.)

The animals used in the experiments recorded in this paper were collected from the shore near the borders of a small stream and between the tide-marks. They were therefore exposed in their natural habitat to a wide diurnal variation of osmotic pressure. Experiments made with whole animals showed that they are capable of living indefinitely in water having an osmotic pressure of more than two and less than thirty-three atmospheres. Experiments on the rate of regeneration of the posterior end only were considered. These showed that the rate of regeneration of the posterior end depends on the osmotic pressure of the medium. This has an optimum value at eighteen atmospheres, and limiting values at five and thirty-five atmospheres.

Restoration of the lost parts in *G. ulvæ* is brought about entirely by the undifferentiated parenchyma cells, which migrate to the region of the wound and form the new tissues. The growth of the new parts is always accompanied by reduction of the old ones. For values of the osmotic pressure lying between the optimum and the limiting values the migration of the parenchyma cells is retarded, and the rate of restoration is retarded to a similar degree. At the limiting values there is no migration and no restoration of lost parts.

G. ulvæ also shows the phenomena of reduction under conditions of starvation. These are (1) absorption of the genital system, (2) general reduction in size. Both of these changes are brought about by the phagocytic action of the parenchyma cells. During regeneration the same reduction processes occur as in starvation. When the restoration of lost parts is retarded, as happens on raising or lowering the osmotic pressure, reduction is retarded to the same extent.

In strongly hypotonic solutions the gut cells increase in size and become vacuolar; in strongly hypertonic solutions they diminish in size and become dense, showing that there has been actual gain or loss of water by the tissues.

D. J. L.

Hydrographical Observations in the Labrador Current in 1913. By Donald J. Matthews. (*Report on the work carried out by the ss. "Scotia," 1913. H.M. Stationery Office, London, 1914.*)

THE *Scotia* was sent out by the Board of Trade in the spring of 1913, under the command of Capt. T. Robertson, to make observations on the amount of ice collected in the Labrador Current to the northwards of the liner tracks, which might prove a danger to shipping later in the year. She was fitted with apparatus for hydrographical work to a depth of 550 fathoms and for meteorological and plankton investigations. The scientific staff consisted of Mr. G. I. Taylor (meteorologist), Mr. L. R. Crawshay (biologist), and the writer.

The *Scotia* left Dundee on March 8th, but was much hindered by bad weather, and did not get clear of the Hebrides till March 23rd. She reached St. John's, Newfoundland, on April 14th, having passed a group of bergs on the Flemish Cap.

The *Scotia* left St. John's again on April 23rd, and steamed first southwards to Cape Race and then south-eastwards across the Banks to the deep water. The surface water had a temperature between 1·5° and 0°; in the deep channel under the coast a minimum of —1·5° or less was reached at 40 fathoms and extended to the bottom in 90 fathoms off St. John's; near Cape Race the lower layers were somewhat warmer. This temperature distribution, with a minimum at some intermediate depth, is characteristic of polar waters; it was not found on the Banks. Warm salt water was encountered off the south-eastern edge of the Banks.

The next run was made northwards along the edge of the Banks and then eastwards beyond the Flemish Cap, and large numbers of icebergs were sighted in spite of almost continuous fog. The Labrador Current extended seawards as far as the western edge of the Flemish Cap; eastwards of this the bergs were melting rapidly in relatively warm high salinity water. Between the Cap and the Banks the polar water was underlaid by water with a salinity of over 34, but the vertical changes were irregular.

The *Scotia* then proceeded to Bonavista Bay, where the characteristic minimum, —1·7°, was found at 70 and 100 fathoms. From this point she worked northwards through or along the edge of pack ice to about 54° N. It had been intended to proceed as far as Hamilton Inlet, but a strong northerly gale made this impossible. The pack encountered during the more northern part of the run was very heavy and in places hummocky, while behind it were countless large bergs driving more slowly before the wind. Observations made on the edge of the pack in about 53° N. showed salinities varying between 33 and 34 down to 100 fathoms, with a temperature minimum of about —1·3° between 25 and 50 fathoms. From 100 fathoms to the bottom in 200 fathoms there was relatively unmixed Atlantic water with salinity and temperature over 34·0 and 0°.

The next run was south-eastwards to the Flemish Cap. The edge of the Labrador Current was passed in about 50½° N., 49½° W., the temperature rising suddenly from 0° to 3° and the salinity from 33·9 to 34·7. Eastwards of the Flemish Cap the salinity and temperature now (May 24th) were much higher than nineteen days earlier, and far fewer bergs were sighted.

On May 28th a buoy fastened to a sinker and drag by 1000 fathoms of piano wire was put over close to a berg on the outer edge of the Labrador Current in about 45½° N., 47° W. The berg was found to be drifting S. 52°E., 0·55 mile per hour, in a smooth sea with scarcely any wind.

The *Scotia* then proceeded to St. John's, passing no more bergs until close under the land.

The second cruise, from June 10th to July 19th, consisted of a series of diagonal courses as far as 44° W., between the parallels of Cape Race and Hamilton Inlet. The finer weather now made scientific work much easier, and a number of vertical series and current measurements were made. The outer boundary of the Labrador Current was clearly defined, at least northwards of the fiftieth parallel, by the isohaline of 34 and a change of temperature of three or four degrees. In conformity with the general rule for oceanic currents it followed the edge of the continental slope closely. Seaward of it the surface temperature and salinity increased eastwards very slowly from 4° to 7° or 8°, and from 34·0 to 34·8. Vertically the water was nearly homogeneous; the temperature fell from 6° or 7° at the surface to 4° at 50 or 100 fathoms, and then very slowly to 3° at 500 fathoms, while the salinity increased from 34·6 or 34·7 to 34·8 or 34·9. Current measurements with a buoy showed almost no motion.

The Labrador Current flowed over the continental shelf where the depths were less than 300 fathoms; it had a salinity of less than 33·5 and a temperature below 0° except where the surface layer had been heated by the sun, and the intermediate temperature minimum was well marked. In places Atlantic water with positive temperatures and salinity over 34 underlay the polar water. Off the Labrador coast the pack had shrunk considerably since the previous run, and now lay westwards of the fifty-fourth meridian. The effect of the melting of the ice showed itself in the decreased surface salinity.

Current measurements with anchored buoys showed weak and variable currents, and in some places the pack lay in an eddy which was actually moving northwards.

From the Labrador coast the *Scotia* proceeded out to the Flemish Cap and then in to Cape Race. On the Banks the surface temperature was as high as 8°, with less than 0° at from 35 to 50 fathoms, while in the deep channel under the land —0·9° was found at 20 fathoms and —1·70° at 50 fathoms. A buoy was anchored for 26 hours in 100 fathoms off Cape Race, where there is normally a set of about one mile per hour to the south and west ; on this occasion the current was found to be setting slowly northwards.

The *Scotia* entered St. John's on July 19th and left again on the homeward voyage on July 24th. A digression was first made for current measurements on the southern part of the Banks. Two complete sets of measurements with the Ekman metre, each lasting about thirteen hours, at 5 fathoms and 25 fathoms, were made in 50° W. at two points about 60 miles apart ; the ship was anchored in 30 fathoms in each case. The current was found to be tidal with a slight easterly resultant, which at 5 fathoms in 43° 53′ N. reached 1·4 miles in the course of a tide ; at the other positions it was less than 0·5 mile. The direction changed regularly through south to west, north, and east.

The *Scotia* then proceeded to the Flemish Cap and Cape Farewell. The East Greenland pack, with about three small bergs, was followed from 59° 6′ N., 42° 27′ W., to 62° 11′ N., 39° 42′ W. Near the edge of the pack the character of the water changed very rapidly, so that some of the ice was floating in water of nearly 35 salinity, with a temperature of 8°. From this point the *Scotia* turned homewards and reached Dundee on August 24th.

During the year 1913 the ice was as a whole held up to the northwards of the forty-third parallel, and the *Scotia* observations make it seem probable that this was due to an easterly set of water from the region off the Cabot Straits and the coast of Nova Scotia, which covered the southern half of the Newfoundland Banks.

The observations were worked up and the report on the hydrographical work written at the Laboratory of the Marine Biological Association, and I wish to express my thanks to the Council and to Dr. Allen for putting apparatus and a table at my disposal for the purpose.

D. J. M.

Report on the Distribution of the Microplankton. By L. R. Crawshay. (*Report on the work carried out by the ss. "Scotia,"* 1913. (*Pages* 68–126, *Plates* 23–35.) *H.M. Stationery Office, London.* 1914.)

THE purpose of the *Scotia* Expedition to the North Atlantic in 1913 having been to study the movement and distribution of the ice in the region of the Labrador Current, the subject of the Report on the plankton investigations concerns the distribution of the microplankton, especially the Diatoms, as regulated by the Labrador Current on the one hand, and by the warm Atlantic water on the other.

The area of investigation extended roughly between 44° and 55° N., and between about 44° W. and the coastal water to the westward.

The species dealt with are very largely neritic forms, characteristic of the polar water, and the distribution of these as contrasted with that of certain oceanic species, especially *Rhizosolenia styliformis*, was found to conform very closely with the distribution of the Labrador water as ascertained by the hydrographic observations. Among the species considered, a third class is distinguished as " intermediate " species, as including those which possess a wider hydrographic range, and of which the hydrographic relations are of chief importance in their bearing on secondary details. Such importance have the distribution of the Peridinidæ in the month of July, after the decline of the neritic Diatoms, and the distribution of *Ceratium arcticum* as compared with that of *C. longipes.*

The report is divided into two sections, dealing with the surface and vertical distribution respectively of the species considered.

The first section is illustrated by a series of charts showing the distribution, as observed over four periods between April and July, of certain of the more important species. These four periods correspond with those observed by Mr. Matthews in the construction of his charts of the physical conditions, with which the plankton charts may therefore be directly compared.

Up till the end of June, the seaward boundary of the neritic species was found to follow, north of the Grand Banks, approximately the 34·50 isohaline and an isotherm somewhat above 4°. Outside the 34·70 isohaline and the 5° isotherm they were only recorded in a single instance, in an isolated patch of 34·50 water, and the whole of this region was tenanted by an abundance of *Rhizosolenia styliformis*, in company with other oceanic species. In the region of the Flemish Cap the neritic species were found spreading out more irregularly to the eastward, to a considerable distance outside the Cap, their distribution between the latter point and the eastern edge of the Banks being much confused with that of the oceanic species. Here also the hydrographic limits of the neritic species were about 34·50 and 5°, though the isohalines and isotherms were very irregular in this region. The southern boundary of the neritic species referable to the Labrador water could not be definitely ascertained, but so far as the investigations extended they were found to be confused with oceanic species along a line between Cape Race and the south-eastern border of the Banks from April onwards.

In the beginning of July, the seaward boundary of the neritic species, north of about 50° N., showed only a slightly more westerly position than was observed in the middle and latter part of June. The most important change during this month concerned the entire disappearance of the neritic Diatoms from the surface water of the northern half of the Banks, and for some distance outside their northern edge, the species being nowhere abundant south of 50° N. The Diatoms were found to be superseded by an abundance of Peridinidæ and other forms, notably Tintinnidæ, the species, however, including also *Ceratium arcticum*, which is generally characteristic of the true Labrador water though not confined to it. These changes occurred concurrently with a general rise in the surface temperatures in this region to 6° and over, and a fall in the salinities, at most points, below 33·00. From several vertical series of water samples which Mr. Matthews kindly obtained for me with the water bottles during the working of his stations it was found, at all points investigated on the Banks and a short way to the northward, that the Diatoms were present in an underlying body of cold water, the upper limit of their vertical range varying from 17 to 40 fathoms or more below the surface. At a station off the southern end of the Flemish Cap these conditions did not occur, and the dominating oceanic species *Rhizosolenia styliformis* ranged from 0 to 50 fathoms.

A second point of importance observed in July concerned the zone of transition between the two forms *Ceratium arcticum* on the north, and *C. longipes* on the south. This was found occurring in the latitude of Cape Race, and southwards to near the south-eastern border of the Banks, in a region where in April, as has previously been stated, the neritic Diatoms of the Labrador water were found confused with *Rhizosolenia styliformis* and other oceanic species. *C. longipes* was in fact once recorded in April in the same region, in about 45° N. and 51° W., and it is probable that the zone of transition between the two *Ceratium* forms was fairly constant in position on the southern half of the Banks from April onwards. There is little to suggest that the transition represents a gradual change in process between two nearly related forms of possibly the same species, prompted by changes in the physical conditions. The observations lead to the view that the origin of each is entirely distinct, that of *C. arcticum* being in the Labrador water on the north, and that of *C. longipes* being in the south and west, a southerly origin being also ascribed to the oceanic Diatoms that were found present here as early as April.

As has been stated, the limitations of the neritic Diatoms as a whole were found to conform closely with the hydrographic boundaries along the outskirts of the Labrador Current, and only at those points where the salinities and isotherms became irregular, as, especially, in the region of the Flemish Cap, did the former become confused. This point is brought out in the very low average temperatures which species show, as compared with those obtained by the International Investigations in the North European waters. For a large number of "abundant" records, *Thalassiosira Nordenskiöldii*, for example, shows an average temperature of 0·9°, as against an International Investigations average of 5·3°; in *T. gravida* the average is 1·4°, as against 6·3°; in *C. sociale* it is 0·9°, against 3·9°. The sharpness of the limitations in distribution usually occurring in this region seems to be due to the suddenness and extent of the change which at most points occurs between the polar and the Atlantic water. At the surface, wave movement was probably accountable for the fact that frequently, when intersecting the boundary of the polar water, a narrow intervening belt was traversed in which both polar and oceanic Diatoms became almost or entirely absent, the conditions being apparently intolerable to both. In the vertical direction, at positions where different layers of water were superimposed, and where little or no such mixing occurred, the vertical range of species was found so sharply defined that it was measurable within a metre or less.

I am indebted to the Council of the Marine Biological Association and to Dr. Allen for having placed all facilities at my disposal at the Plymouth Laboratory for the examination of the material and the preparation of the report.

L. R. C.

Contributions to the Comparative Anatomy of some British Actiniæ.

By

Olwen M. Rees, B.Sc.,

Zoological Department, University College of Wales, Aberystwyth.

With Figures 1–16 in the Text.

The main object of this paper is to give a comparative anatomical description of some British Anemones as well as to describe each individually; but the account is not so full as it was expected to be, as it was not possible to get all the species required.

In most cases the specimens were examined externally before sections were cut. Each specimen was prepared according to the usual method used with paraffin wax, and I found during the progress of the work that borax carmine was the stain which gave the most satisfactory results.

I should like to thank Miss E. de Fraine, D.Sc., Mr. F. W. Durlacher, and Mr. F. S. Wright for much assistance in the course of the work.

For specimens collected and sent I am deeply indebted to Dr. E. J. Allen and his staff at Plymouth, Miss Delap, of Valentia Island, and Monsieur Louis Fage, of the Laboratoire Arago, Banyuls-sur-Mer, France.

Fam. **SAGARTIDÆ** (Gosse, 1858).

"Actiniinæ with a contractile pedal disk; body-wall smooth, or provided with verrucæ or tubercles, and usually perforated with cinclides, with or without a cuticle. Tentacles usually numerous and retractile, not very long, smooth, simple and generally entacmæous, sphincter muscle characteristically well developed and mesogloeal, occasionally diffuse endodermal, or even absent. At least six pairs of mesenteries, may be fertile or sterile. Acontia present." The above is the definition used by Haddon in "The Actiniaria of the Torres Straits" in 1898. There has been a great deal of discussion concerning this family.

Many other authors in defining the family include the provision of the "sphincter muscle mesogloeal." This is not important, as Bourne has shown the presence of an endodermal sphincter in Metridium (Actinoloba). Again, other authors define this family as "Hexactiniæ furnished with acontia."

SUB-FAMILY. SAGARTINÆ (Verrill).

" Sagartidæ with naked ectoderm. Cinclides usually present." (Haddon.)

Genus SAGARTIA (Gosse, 1855).

" Sagartinæ with smooth body-wall ; margin tentaculate ; sphincter fairly strong ; tentacles concealed in contraction." (Haddon.)

Sagartia miniata (Gosse).

Gosse regarded *S. miniata* as the type species of his genus Sagartia. Gosse had made the possession of two œsophageal grooves one of the important characters of the genus, but now it has been proved that many of the typical Sagartids possess one as often as two grooves.

Specimens of *S. miniata* were kindly sent here by Miss Delap from Valentia Island. When they arrived they were still alive, but not in a condition fit for observation.

Column colour varying shades of orange, passing from pale below to either a dark chocolate, or purplish at the summit. Suckers irregularly arranged, but more numerous and conspicuous near the summit.

Tentacles of the outer cycle all possessed the crimson core and showed the following variations :—

(*a*) Light orange-crimson core.
(*b*) Lake, with orange-crimson core.
(*c*) Pale flesh-coloured, with light orange-crimson core.

Tentacles of inner cycle dusky, with indistinct white bar across inner face.

Tentacles of the Middle Series, crimson lake, resembling those of *S. rosea*.

Tentacles of the Marginal Series, usually pale reddish white, with three black patches on the inner face and a yellowish area about the base. This specimen had also a white transverse bar at the tentacle foot within the dark area on the periphery of the disk. Acontia white, very freely emitted.

The following are the measurements taken from a preserved specimen:—

Diameter of pedal disk	13 mm.
,, ,, column	7 mm.
Height of column	18 mm.
Length of tentacles	3 mm.

Comparing the size of this specimen with that of *S. viduata* described by Carlgren in " Studien über Nordische Actinien," 1893, I find that

S. miniata is a much smaller anemone, *S. viduata* being about 50 mm. long and 15 mm. broad. *S. viduata* is also characterised by grey, green, and brown colours instead of the lake, orange, and crimson found in *S. miniata*. In *S. viduata* the warts (which Gosse called suckers) lie in the upper third of the column. The cinclides open in the middle of these prominences. In *S. miniata*, the cinclides seem to be very few, opening, as in *S. viduata*, in the middle of some of these prominences near the oral disk.

Arrangement of the mesenteries.

In *S. viduata*, Carlgren has found a definite number of mesenteries, i.e. 96 pairs, including two pairs of directives, arranged in five cycles thus,—6+6+12+24+48. The last cycle is represented by mere projections of tissue developed in the lowest part of the column. In this species the arrangement coincides with the number and arrangement of the tentacles which are in 6 cycles, 6+6+12+24+48+96=192. I have cut sections of several specimens of *S. miniata* but am unable to make out any definite plan of the arrangement and number of mesenteries. The same difficulty has arisen in connection with other members of this genus, in *S. venusta*, *S. troglodytes*, and *S. nivea*.

In his paper "On the arrangement of the mesenteries in the Genus Sagartia," in *Proc. R.D.S.*, 1888, F. Dixon says that he was unable in most cases to recognise a completely hexamerous arrangement of the mesenteries. The only regularity seen was the correspondence of the number of directives with that of the œsophageal grooves. Dixon gives the number of mesenteries, etc., from three specimens collected near Dalkey Island. The following data are taken from three specimens from Valentia Island, probably older and larger than those examined by Dixon :—

Specimen (*a*) : 20 pairs of mesenteries reaching the œsophagus, including 1 pair of directives. There is 1 œsophageal groove present. About 20 pairs belong to 2nd cycle and are incomplete. The 3rd cycle consists of about 40 small mesenteries which penetrate only a very short distance into the cœlenteron.

Specimen (*b*) : This has 24 pairs of mesenteries reaching the œsophagus, including 2 pairs of directives arranged in the order :

D. 9, D. 13.

The 2nd cycle consists of about 24 mesenteries, and the 3rd cycle of about 48 ; these latter project only a short distance beyond the column wall. There are 2 œsophageal grooves here.

Specimen (*c*) : This showed 1 œsophageal groove and 1 pair of directives. The number of mesenteries reaching the œsophagus was about 24 pairs, including the directives.

The column wall is strong, the mesogloea being much thicker than the ectoderm. The ectoderm has a spongy appearance and contains a large number of gland cells, which are arranged near the outer margin, and most of them contain a granular substance like those of *S. viduata*. The opening of the cinclides is like that described and figured by Carlgren for *S. viduata;* the canal consists exclusively of ectoderm, endoderm only beginning at the inner end.

The mesogloea has a fibrous appearance when examined under a low power of the microscope, but under the high power, the cavities of the cells give it an almost spongy appearance. The cells become smaller and the whole mesogloea becomes stronger near the endodermal margin, and this gives rise to an endodermal muscle. As in *S. viduata* this is fairly well developed and much folded in transverse section. The folds are not branched and are irregular in shape. In the upper part of the column the muscle is differentiated into a mesogloeal sphincter which is very strong especially at the top, diminishing downwards. There are numerous mesogloeal processes projecting into the endoderm, and they are deeply set and are often branched. These projections are not present in the sphincter muscle of *S. viduata* as figured in "Nordische Actinien." The endoderm of the column wall is of about the same thickness as the ectoderm and contains numerous zooxanthellæ; and the number of these increases on the mesenteries, especially in the region near the œsophagus.

The primary mesenteries all have a large and well-developed retractor muscle.

As in *S. viduata* and *S. undata*, the muscle cushions of the directive septa are quite near the œsophagus, while those of the remaining septa are nearer the middle of the septa. The former are more concentrated and higher than the latter, which are extensive and more shallow. The retractor muscle is of the usual shape and contains a large number of arborescent folds.

In the largest specimen (*c*) this muscle in section was divided up into a number of folds, each fold being supplied with numerous mesogloeal fibres, as shown in the figure (Fig. 1). In this way the whole septum is very much elongated.

The parieto-basilar muscle is well developed and appears very long in cross section, and most of the mesogloeal processes arise from the side on which the retractor muscle occurs. These processes are not numerous

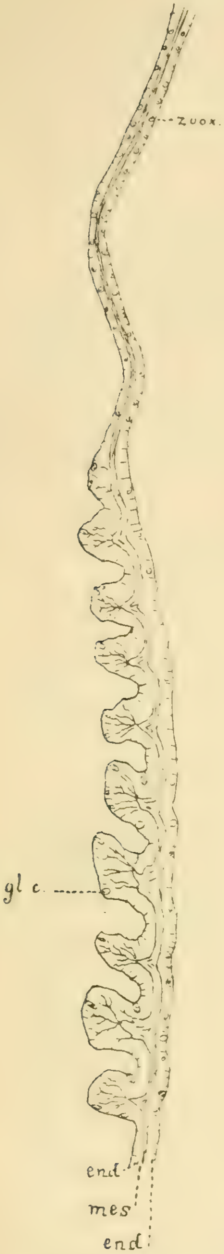
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*Fig. 1.—*Sagartia miniata.* Transverse section of a portion of a mesentery from a large specimen, showing the curious folding of the retractor muscle.

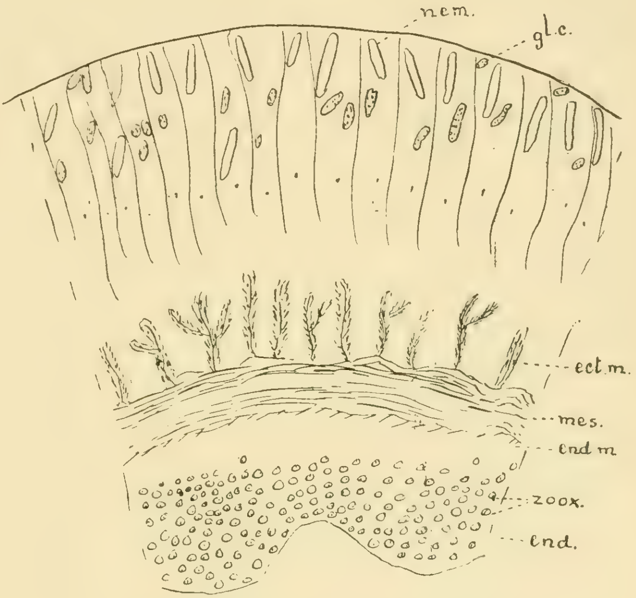
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Fig. 2.—*Sagartia miniata.* Portion of the tentacle wall, showing the strongly developed ectodermal muscle.

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* For Index to Lettering, see page 552.

and are very small near the base, but get large in the region near the retractor muscle.

Many of the mesenteries which are incomplete develop sex organs and mesenterial filaments. The latter have three distinct lobes.

The stomatodæum is very long and in cross section is triangular in shape in all the specimens that I examined, because in each case the specimen was more or less contracted. This triangular shape is due probably to the equal pressure exerted by the mesenteries on the cylindrical œsophagus during contraction. The wall is raised into numerous folds, the number and position usually corresponding to the number and attachment of the mesenteries reaching the œsophagus. The ectoderm of this region is characterised by its large number of spindle-shaped granular gland cells. The mesogloeal process in each fold is unbranched and generally pointed at the tip.

Oral stomatopores were found in all the complete septa. These are very small and lie between the retractor and the parieto-basilar muscles, as in *S. viduata*. The tentacle (Fig. 2) is characterised by a remarkably strong longitudinal muscle in the ectoderm. The mesogloeal folds are very deep, are branched, and numerous. There is a distinct endodermal muscle, the endoderm is folded and the zooxanthellæ are very numerous. Gland cells and nematocysts are present in the ectoderm of the stem and tip of the tentacle.

Sagartia ornata (Holdsworth).

The specimen here described was found attached to the under surface of a stone in a pool on the reef near the Castle, Aberystwyth, just below ordinary low-water mark, on October 3rd, 1913. This species has been previously recorded from the same and from adjacent localities.

Form : base exceeding column and irregular in outline ; the specimen was never seen fully expanded in the day time and only partially so at night. Soon after its capture it left the stone and attached itself to the vessel in which it was kept, and there remained firmly attached and much flattened.

Column, according to Gosse, " minutely corrugated, studded on the upper half with ' suckers,' more numerous as they approach the summit." A fair amount of mucus was given off from time to time. The tentacles appear to be about 96, probably arranged in the following cycles : 6+6+12+24+48. They are rather short and obtuse at the tip.

Disk (seen only by artificial light), mouth appeared slightly raised, lips somewhat thickened. Œsophageal grooves could be distinguished. Acontia, one was seen emitted from the mouth.

Colour: column buff, paler at base, with numerous faint longitudinal lines best marked near the base.

Disk pale yellow in the centre, darker on the outer area, radii paler. A cycle of twelve distinct, nearly circular white spots is situated at the junction of the two-colour areas.

Tentacles dark chocolate-brown or mahogany, paler towards the tips; the tentacles of outer cycles are paler than those of the inner, and have the basal bar more prominent. Innermost tentacles more or less dusky, but always darker on their inner faces. There are three or four white bars on this side; Holdsworth calls them "rings," but if so they are very indistinct on their outer faces. The apical bar is often very faint or barely visible; the basal bar, the third or fourth from the tip, is very distinct.

The following measurements were taken from a preserved specimen:—

Diameter of pedal disk = 7 mm.
,, ,, oral disk = 3·5 mm.
Height of column = 4 mm.
Length of tentacles = 2 mm.

Arrangement of the mesenteries: This specimen shows an hexamerous arrangement. There are four cycles, 6+6+12+24=48. The mesenteries of the first two cycles are fully formed bearing reproductive organs and mesenterial filaments. There are two pairs of directives and two œsophageal grooves. The 4th cycle of mesenteries is only slightly developed.

The column wall is not very strong, the mesogloea being less than half the thickness of the ectoderm. The latter is a broad layer consisting of tall columnar cells, which seem to get broader near the outer edge. This ectoderm has an appearance quite different from that of *S. miniata*, where it is more spongy and the cells are neither so regularly arranged nor of such a uniform size as those of *S. ornata*. Gland cells seem to be absent in the ectoderm of the column wall.

The mesogloea is not very dense and a fibrous structure is distinctly visible; the fibres are very fine and form a close network, which becomes denser near the endoderm. The mesogloea is not of uniform thickness, because the ectoderm is raised into folds and these are supported by processes of mesogloea, at any rate in a state of contraction. In transverse sections near the summit of the column I have found a few cinclides, but I have not found them present between two septa of a pair, as Carlgren found in *S. undata*. The structure of these openings is the same as that described for *S. viduata* and *S. miniata*; they are ectodermal invaginations.

In the mesenteries (Fig. 4) of the first two cycles the parieto-basilar is comparatively strong; it is slightly constricted near the base, and is an elongated muscle. Most of the muscle folds are given off on one side only. These folds are short and stout, sometimes globular at the head, sometimes slightly branched. Before the parieto-basilar muscle passes into the retractor muscle the former becomes swollen and a projection of the mesogloea sends out a number of branches towards the edge away from the retractor muscle.

The longitudinal retractor muscle is rectangular in section and has an appearance quite different from that of *S. miniata.* In the latter the muscle folds are delicate and very numerous—about 80 in number; while in *S. ornata* the folds are fairly short and stout and number only about 10–20.

Oral stomatopores are present in the complete mesenteries, and there are slits between the retractor and parieto-basilar muscles.

The mesenteries of the third cycle reach about half-way across the cœlenteron. Each mesentery has a stout axis of mesogloea, which gives off about five branches.

The mesenteries of the 4th cycle are present in the lower half of the column only. They are very small and are indicated by a thin projection of mesogloea surrounded by a layer of endoderm.

Stomatodaeum. The two œsophageal grooves are well marked. The ectoderm is thick and has a granular zone near the free surface. The mesogloea is thick near the base of the groove, but becomes thinner along the sides of the groove. The wall of the stomatodaeum is raised into about 24 deep folds, corresponding to the number and attachment of the mesenteries, and the ectoderm of these folds contain a large number of gland cells whose contents are not granular.

The sphincter muscle (Fig. 5) is a mesogloeal one. It is very much like that of *S. milmani* (H. and S.) figured by Haddon in *Trans. R.D.S.*, 1898. The cavities in the muscle are large and numerous and tend to radiate in the same direction as shown in the figure. The broadest region is near the summit, while lower down in the column wall the muscle becomes very narrow and the cavities become fewer. The gland cells of the ectoderm in this region contain a number of spherical bodies which are highly refractive.

Tentacles. Near the tip the ectoderm is more than twice as thick as the rest of the tissue. In a section through this region of a tentacle there are very numerous nematocysts, some seen in section and some seen from the side. They are fairly short and stout, spindle-shaped bodies, and a fine, much-coiled spiral thread is faintly distinguished in one or two cases. Near the base of the tentacle (Fig. 3) the endoderm is narrower and the nematocysts, although very numerous, are fewer in number than above. The mesogloea is not strong and in some cases is reduced to a fine strand.

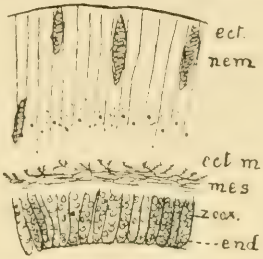
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FIG. 3.—*Sagartia ornata.* Portion of a transverse section from near the base of a tentacle.

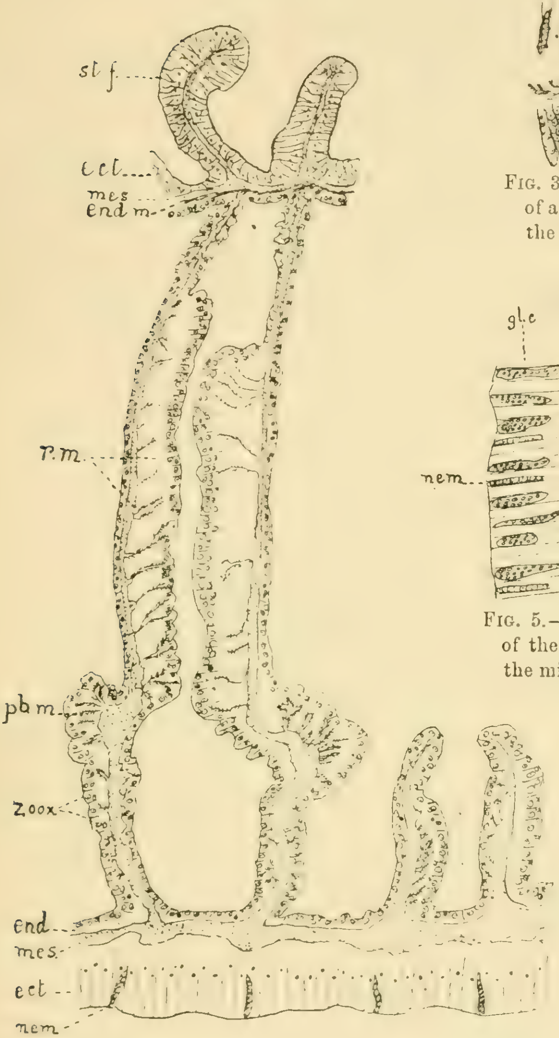
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FIG. 4.—*Sagartia ornata.* Portion of a transverse section through the column, showing two complete mesenteries and two mesenteries of the third series.

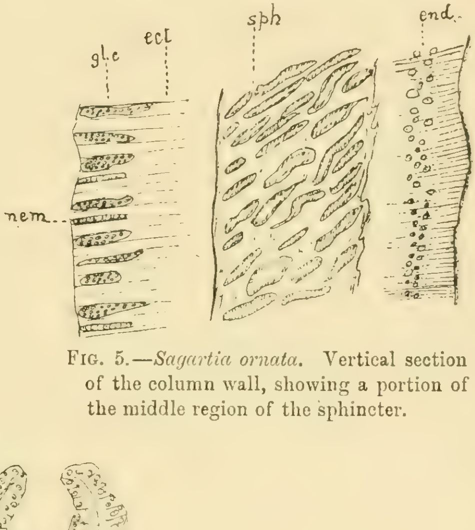
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FIG. 5.—*Sagartia ornata.* Vertical section of the column wall, showing a portion of the middle region of the sphincter.

At the point where the tentacle joins on to the peristome the tissues are much thicker, the nerve layer is much broader, and there is a stronger ectodermal muscle. The mesogloea is thicker and has a plaited appearance. The cells of the endoderm have a columnar structure, but the inner margin of that region appears to be very irregular; some of the cells project farther into the cavity than others.

Zooxanthellæ are present in the endoderm.

Sagartia sphyrodeta (Gosse).

The specimen described here was sent from Plymouth. It was killed expanded and preserved in formalin. It was left for a considerable time before being examined, so that the structure of the tissues was in many places obliterated, and the colouring could not be verified. The tentacles are arranged on an octamerous plan: 8+8+16+32=64. This number of tentacles is usually found in Plymouth specimens. Gosse found only 48, arranged thus: 8+8+16+16; and Fisher, in 1874, gives 8+8+16+32+64=128.

Measurements were taken from the preserved specimen as follows:—

Diameter of tentacular crown	=18 mm.
,, ,, disk	=7 mm.
Length of primary tentacles	=5 to 6 mm.
,, ,, outer ,,	=3 mm.
Diameter of pedal disk	=6 mm.
Height of column	=4 mm.

The body-wall is weak, the mesogloea forming a very thin, fibrous strand between the endoderm and the ectoderm. The endoderm is about half the thickness of the ectoderm. Near the cinclides the ectoderm is very much swollen in each case; these openings are few and are found near the upper part of the column. The acontia have large gland cells, nematocysts, and granules.

The sphincter muscle (Fig. 6) is in shape very much like that figured for *S. carlgreni* by Haddon and Duerden in *Trans. R.D.S.*, 1896. It is not nearly so long as that of *S. milmani*, and the cavities are more numerous than in the sphincter of *S. carlgreni*.

The mesenteries (Fig. 7) are very weak, the retractor muscle forms a shallow cushion, and the parieto-basilar muscle is very long and thin. The endoderm contains numerous oval gland cells, which are full of deeply stained granules.

The œsophagus has one groove; the folds in the ectoderm of the wall are neither so deep nor so regularly arranged as those examined in *S. miniata* and *S. ornata*.

In the upper part of the column wall a very strong radial ectodermal muscle is present; an endodermal muscle is also present. There are three distinct lobes to the mesenterial filaments (Fig. 8); they are shaped differently from those figured for *S. milmani*.

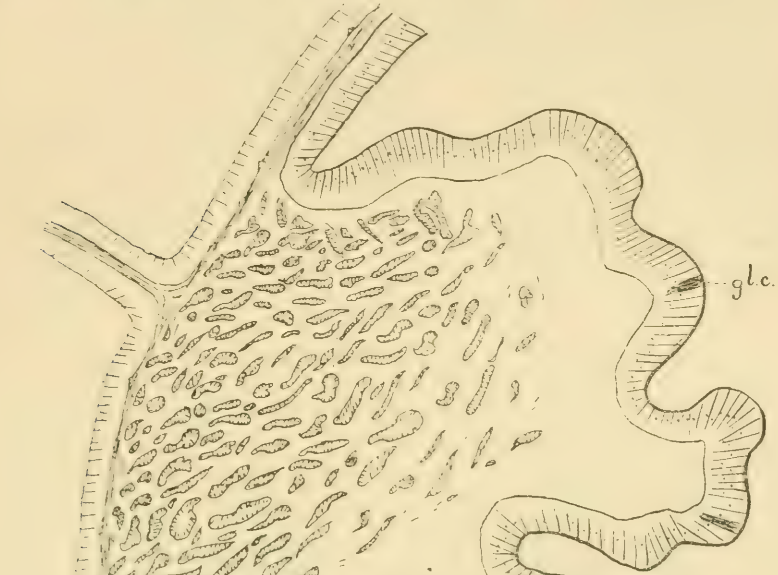
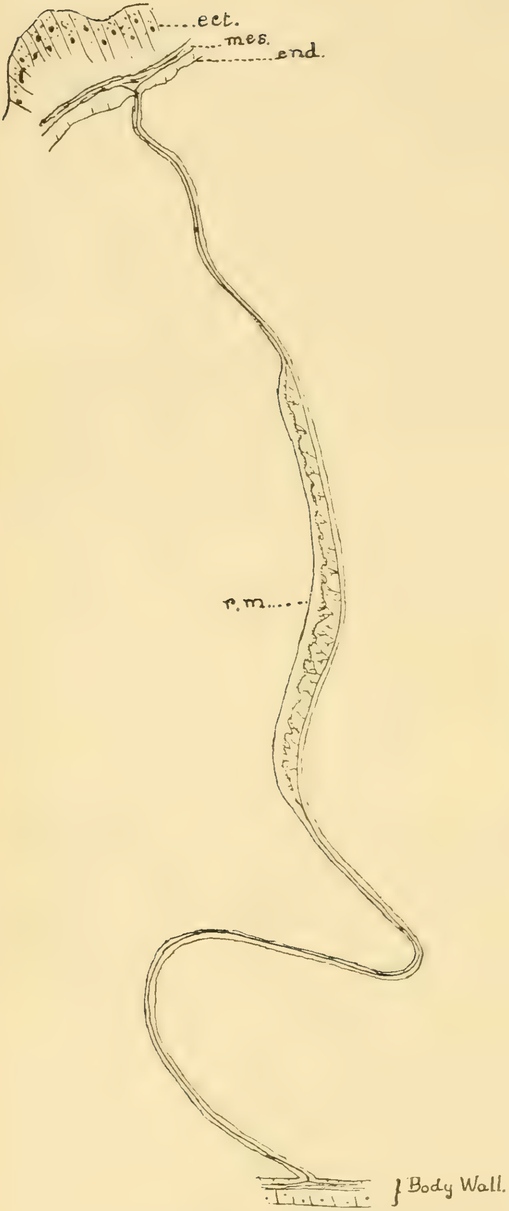


FIG. 6.—*S. sphyrodeta*. Vertical section through the body-wall, showing the sphincter muscle.

The mesogloea in the tentacle is very weak and the endoderm forms a very thin layer.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Body Wall.

FIG. 7.—*S. sphyrodeta.* Transverse section through a young specimen in a fully expanded condition, showing one of the perfect mesenteries.

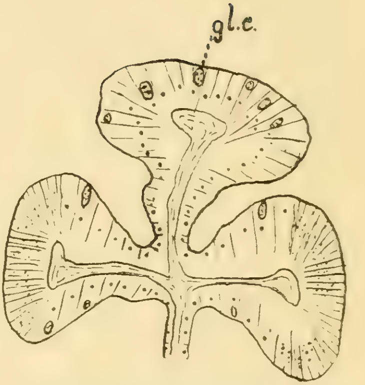

FIG. 8.—*S. sphyrodeta.* Section through the trilobed mesenterial filament.

S. sphyrodeta resembles *S. milmani* (H. and S.) in the following respects :—

1. The mesogloea is not thick.
2. The mesenterial filaments are weak.
3. The parieto-basilar muscle is very feeble ; only a few small folds can be seen on the side of the mesentery bearing the retractor muscle.

With regard to character and shape, the sphincter of *S. sphyrodeta* resembles the sphincter of *S. carlgreni*, but the arrangement of the mesenteries is quite different in the three species.

S. milmani has 48 mesenteries, among which a sex radiate symmetry is maintained thus : 12+12+24. There are two pairs of directives arranged thus :—

D. 4, D. 6.

In *S. carlgreni* the mesenterial formula is 6+6+12+24=48.

In *S. sphyrodeta* there is one œsophageal groove and one pair of directives.

The mesenteries are irregularly arranged and I am unable to make a mesenterial formula. Since the tentacles are arranged on an octamerous plan we should expect the mesenteries to be arranged in the same way. In a young specimen I counted 20 pairs and one odd mesentery. Some of these were complete and bore reproductive organs, the others were rudimentary. In an older specimen there were 48 pairs of mesenteries arranged, probably, in four cycles.

The mesenteries of this species are stronger and the retractor muscle forms a definite cushion with branched muscle folds.

COMPARATIVE TABLE OF BRITISH SPECIES OF SAGARTIA,

Anatomical Features.		Data given by O. Carlgren, Stud. über Nord. Act. Kongl. Sv. Vet. Akad., Bd. 25, No. 10.			
		S. viduata.	*S. undata α.*	*S. undata β.*	*S. undata-troglodytes.*
Column Colour.		(Norway.) Ground colour grey-green, yellow-brown or green lines.	(Norway.) Red-brown or dull brown, small flesh-coloured stripes.	(Norway.) Red spots on white or flesh-coloured ground.	(Norway.) Salmon or flesh colour, sometimes grey-green.
	Not Carlgren's Data.	(Great Britain.) Ground colour pinkish buff, white or yellowish lines.	(Great Britain.) Olive-green, brown, grey, pink, numerous longitudinal stripes. Gosse recognised about 20 varieties.		
Disk Colour.		Ochreous grey radial lines, green or yellowish spots.	Ochre-orange radial lines. B. mark at tentacle basis.	Brownish or orange with white lines. Red or red-brown B. marks at tentacle bases.	White to ochre lines on grey or grey-black ground. Black B. marks at tentacle bases.
Tentacles.	Form.	Fine, tapering, often branched.	Tentacles	long and	tapering.
	Order.	6+6+12+24+48+96=192.	6+7+13+26+52=104.	In 6's or 5's or 8's.	In 6's.
Mesenteries.	Order.	6+6+12+24+48=96.	In 5's or 7's.	Usually in 8's.	6+6+12+24=48.
	Directives.	Two pairs of directives.			
Œsophageal Grooves.		Two grooves.	Two grooves or one groove—sometimes three grooves.		
Column Structure.	Strength.	Strong.	Firm.	Firm.	Firm.
	Relative strength of ectoderm and mesoderm.	E. and M. of same thickness.	E. and M. of same thickness.	E. and M. of same thickness.	E. and M. of same thickness.
	Sucker-warts.	Small, cinclides open on some.	Never	distinct.	Common on upper part, cinclides open on some.
Sphincter.		Mesogloeal, strong at the top.	Mesogloeal muscle masses radial and more rounded than in *S. viduata*.		
				This is possibly identical with Gosse's (not Müller's) *Sagartia coccinea* according to Carlgren.	

FOR WHICH ANATOMICAL DATA ARE OBTAINABLE.

S. miniata (from 3 British specimens).	*S. ornata* (from 2 British specimens).	Anatomical Data given by Messrs. Dixon, Proc. R. Dubl. Soc., 1888-9, etc.		*S. sphyrodeta* (from 3 British specimens).
		S. nivea.	*S. venusta.*	
Orange. Pale below, dark chocolate above.	Buff, pale at base, with numerous longitudinal lines.	Pale brown with white lines.	Upper half buff to brown, lower half paler with faint white stripes.	White with dull drab stripes, some varieties yellow.
Centre olive to orange whitish radial lines.	Umber to purple-brown. Yellow radial lines with white spots between.	White to olive.	Varying shades of orange.	White, sometimes yellow, with radial lines.
Tapering.	Short, with obtuse tips.	Tapering. Outer cycles may be reduced to papillæ.	Tapering. Outer cycles may be reduced to papillæ.	Short and stout, thickened towards the base.
Difficult to estimate. Probably in 6's.	6+6+12+24+48 =96.	6+6+12+24+48 +96=192.	6+6+12+24+48 +96=192.	8+8+16+32=64.
Either 20+20+40 =80, or 6+6+12 +24+48=96.	6+6+12+24+48 =96.	6+6+12+24=48.	6+6+12+24+48 =96.	Either 5+5+10=20, or 6+6+12+24 =48.
One or two pairs of directives.	2 pairs of directives.	1 pair of directives.	1 pair of directives.	1 pair of directives.
One or two grooves.	Two grooves.	One groove.	One groove.	One groove.
Strong.	Weak.	Moderate.	Strong.	Weak.
E. thinner than mesoderm.	E. twice as thick as mesoderm.	M. thicker than E.	M. irreg. thicker than E. in many places.	Mesoderm thin.
Around summit of column, oval. A few cinclides, open on some of the warts.	Numerous on the upper half. A few cinclides, open on some of the warts.	On upper half, some on upper third perforated by cinclides.	On upper half, some on upper third are perforated by cinclides.	Few, found on upper part of column, perforated by cinclides.
Mesogloeal, strong at the top, diminishing downwards, projections into the endoderm.	Mesogloeal, not so broad at top as in *S. sphyrodeta.*			Mesogloeal, fairly broad at top.

Anthopleura alfordi (Gosse).

Classification.—Family Cribrinidæ, McMurrich (=Bunodidæ, Gosse).
Genus, Anthopleura, Duchassaing et Michelotti (=Aulactinia, Verrill).

The following definition of the genus is that given by McMurrich under the name of Aulactinia: "Bunodidæ with the upper portion of the column provided with longitudinal rows of verrucæ, the lower portion being smooth. The margin forms a more or less distinct collar, and the tentacles are polycyclic and entacmæous. The six pairs of mesenteries of the first cycle are alone perfect."

Haddon has queried the last statement of the above [11, page 442] because he includes in Aulactinia a species *Aulactinia gelam* (=*Condylactis gelam*, Hadd. and Shackl., 1893) from the Torres Straits which has more than six pairs of mesenteries.

The specimen of *Anthopleura alfordi* which I have examined also has more than six pairs of perfect mesenteries. Therefore if these two species, *Anthopleura gelam* and *Anthopleura alfordi*, are to be included in the genus Aulactinia, the definition of the genus will have to be slightly altered (see end of this section).

Externally, the genus Aulactinia differs from the genus Cribrina (Bunodes) in having suckers in the upper portion of the body-wall only; whereas the latter genus is more or less uniformly tuberculated. Delage and Hérouard in describing the genus Aulactinia say that there are four or five cycles of mesenteries, but in this specimen of *A. alfordi* I have found only two cycles, one of complete mesenteries and another of incomplete mesenteries; there is no indication of a third cycle.

The external characters of this species have been described by Gosse (*Ann. Mag. Nat. Hist.*, 3rd Series, Vol. XVI, 1865), under the name *Ægeon alfordi* of the family Antheadæ.

The specimen which I have examined was kindly sent from Valentia Island by Miss M. Delap, in May, 1914.

External characters: (The animal was living, but moribund after the long journey.) The following description applies to the above specimen:—

Pedal disk: outline slightly irregular, in size scarcely exceeding column; wrinkled and appears capable of but slight adhesion.

Column somewhat changeable in form; at times widest about the middle, at others considerably expanded at the summit. Substance somewhat lax. The margin is crenulated with a series of larger irregular warts—the acrorhagi. The warts get smaller in the region near the base, as shown in the figure included by Gosse in his paper. Many of the vertical rows of warts die out rapidly downward, while even the primary rows become faint and the warts distant; the whole of the intervening space is wrinkled (probably owing to the animal being partially contracted).

Tentacular disk: diameter exceeding that of column; mouth rather large, lips somewhat pouting, gonidial tubercles or acrorhagi prominent and inflated.

Tentacles stout, lax, of no great length, tapering but slightly to an obtuse tip, conical during contraction. When the animal is not fully expanded there is a distinct fosse between the margin of the warted column and the base of the tentacles. Tentacles contractile, but not retractile, bear a considerable resemblance to those of Aiptasia. Owing to the laxity of the tentacles it was extremely difficult to make a correct enumeration, or even to determine the number of series. There appear to be about a hundred tentacles, probably in the order $6+6+12+24+48 = 96$. Fragments of sand adhered to the column wall, this suggests the presence of either numerous small suckers or adhesive mucus.

Colour: pedal disk pale yellowish white with a few small red streaks.

Column pale yellowish green, but so thickly covered with minute irregularly shaped red specks as to appear brick-red to the naked eye; only a few specks can be distinguished without a lens. There are also longitudinal series of larger spots of clear yellow-green, each with a bright red central dot; these spots are irregularly shaped and are well spaced in the series, nearer together and more prominent near the summit, where they are seen on the warts. The acrorhagi are of a leaden grey hue with several dull red spots on each. There are fifteen or sixteen of these red-centred spots in each linear series, and the spots are connected by faint lines of yellow-green. There is also a number of intermediate series of these red-centred dots on the upper part of the column, but these soon die out lower down. Thus the column possesses 24 longitudinal pale greenish yellow stripes, each of which contains 15 to 16 spots of a brighter yellow colour, with a bright red central dot.

Tentacular disk: stomatodaeum white, lip pale grey. Disk iridescent, umber or bluish green (according to the incidence of light) succeeded by an indefinite area of dull greyish white. The tentacle bases are of a much darker umber, the gonidial radii are fairly well demarcated and the mesenteries appear as faintly marked radial lines.

Tentacles umber, the inner faces shaded with iridescent purple.

There are numbers of irregularly shaped spots of a pale yellow colour scattered over the inner surface of the tentacles. Each tentacle from the inner series has two opposite, lateral, irregular patches of white, situated about one-third the length of a tentacle from the base. The purple shade is strongest upon the central area of the inner surface of the tentacle.

The series of minute spots is described by Gosse and their presence seems to be characteristic of this species. Haddon does not mention their presence in *A. gelam*.

Size: diameter of column very variable during life, 6–10 cm. Column 15 cm. in height, but probably capable of much greater extension. Diameter of disk about 10 cm. Expanse of tentacular crown about 20 cm. Length of larger tentacles 7 cm. Average diameter of pedal disk 7 cm.

This specimen is about the same size as *A. gelam*; the height of the column of the latter being 150 mm. The specimen of *A. alfordi* collected by Gosse was also fairly large, the height being about 100 mm., it was obtained in the Scilly Isles.

The specimen from Valentia Island disgorged a partially digested Actinian—probably a Cerianthus; a number of these were packed with the Aulactinia and were in contact with it.

Anatomy and Histology:—

The column wall is thick, the mesogloea being broader in section than the ectoderm; the latter is deeply folded. The cells of the ectoderm are long and narrow; they contain numerous granules, which become deeply stained. These granules form a broad zone in the ectoderm. On the outside of the layer is a clear zone, and on the inside near the mesogloea is another narrower zone, which marks the position of the nerve layer. Between these two lie the granules.

The mesogloea is thick, stains deeply and is homogeneous in structure. The large spaces which are seen in the sections are probably due to the fact that the specimen became very hard before the sections were cut, and this caused the mesogloea to break.

On its endodermal border the mesogloea shows a delicate fibrous structure, giving rise to a thin plate of circular endodermal muscle. There is no trace of any ectodermal musculature.

The endoderm is a much narrower layer; in section it is about half the width of the ectoderm and one-third the width of the mesogloea. The cells of the endoderm do not show such a definite columnar structure as those of the ectoderm, and the cells are not so regularly arranged.

The spherical granules seen here are of the same kind as are found in the ectoderm. They are more numerous near the free border of the endoderm. Zooxanthellæ are present in the endoderm of the column wall, but are not very plentiful.

There are 24 pairs of fully developed mesenteries, 2 pairs being directives. Alternating with these are the secondary mesenteries, so that in all there are 24 primary pairs and 24 secondary pairs, making 48.

The number of tentacles is the same as that of the mesenteries. All the primary mesenteries except the directives are fertile, and in this specimen bear gonads. The musculature in the mesenteries is strongly developed, especially in the region near the column wall (Fig. 10). The parieto-basilar muscle is cordate in shape with a stout projection on the side towards the intramesenterial space. The mesogloea forms a short stout stem where the muscle is attached to the column wall. The muscle then broadens out rapidly, giving off short processes on either side, and these are sometimes slightly branched. Most of them are narrow at the base, and widen out into broad spherical knobs at the distal ends. There are between 9 and 15 of these branches on either side. One side of this muscle is continued into the large retractor muscle ; this is very wide in the region near the column wall, but becomes narrower towards the distal end of the mesentery, where it is continued into a very narrow plate of tissue. The mesogloea continuing from the parieto-basilar muscle becomes slightly narrower before it enters the retractor muscle and is very thin where it enters the filament. On one side, the mesogloea has short stout projections, these send out long and delicate strands which are much branched. These strands are so numerous that they are not easy to count ; the folds, including their chief branches, number between 80 and 100.

At the distal end of the muscle the folds radiate towards the middle line. No mesogloeal processes are given off on the other side of the muscle. The endoderm is continued from the column wall, along both sides of the mesentery ; it is slightly narrower here and contains some zooxanthellæ. In some parts deeply stained glandular cells are seen.

The secondary mesenteries are very stout, but reach only a short distance into the cœlenteron. They consist chiefly of a parieto-basilar muscle which appears to be almost fully developed. The retractor muscle is beginning to be formed showing a feathery bunch of muscle folds. In some cases these folds are pressed back owing to the development of large gonads.

The mesenterial filaments contain large gland cells the contents of which are granular and take stain deeply with borax carmine. There is also a number of nematocysts, some of which are very large ; these are spindle-shaped and do not stain. I am unable to detect the spiral coil in any of the nematocysts of this region. There are also a few nematocysts scattered about. It is very difficult in this specimen to follow the mesenterial filaments, because the gonads tend to push them together into one mass. I can distinguish only one lobe at the tip of each filament and in most cases this is rounded. In the directive mesenteries the lobe is pointed at the tip.

There are two œsophageal grooves, one of which is better developed than the other. The ectoderm is of uniform thickness along the groove ; there is present a wide zone formed by the granules, as in the ectoderm of the column wall. There are no nematocysts or gland cells here, this ectoderm resembling that of the column wall. Beyond the groove the ectoderm is deeply folded, the folds being supported by processes of mesogloea. Gland cells and nematocysts are present on these folds.

The ectoderm of the peristome (Fig. 12) possesses a large number of the gland cells, also a large number of spindle-shaped bodies filled with dark granules, probably empty cases of nematocysts filled with zooxanthellæ. The number of gland cells increases rapidly towards the entrance of the mouth, and the ectoderm in this region is raised into folds supported by mesogloeal processes.

The sphincter muscle (Fig. 11) is situated along a line joining the bases of the acrorhagi. It is a well circumscribed endodermal muscle and seems to be very much like that of *Aulactinia gelam* figured by Haddon (Plate XXVIII, Fig. 6). In a vertical section of the oral disk it arises from the outer wall near the base of the acrorhagi. It is almost circular, and the surrounding endoderm contains numerous zooxanthellæ. The pedicle is very short and stout, and gives rise to numerous delicate muscle fibres. These are much finer and more numerous than those of *A. gelam.* They branch frequently near their tips, but are not so arborescent as those of *A. gelam.* In a transverse section of the tentacle cut near the base (Fig. 9) the ectoderm contains numerous spindle-shaped and rectangular nematocysts. The spiral coil cannot be distinguished and many gland cells are present. A nerve layer at the base of the ectoderm cells is broad and distinct. The mesogloea consists of a narrow layer of homogeneous structure, except in some parts where it is slightly fibrous. There is a distinct ectodermal muscle, processes of the mesogloea being pushed out on the ectodermal side. There is no indication of an endo-

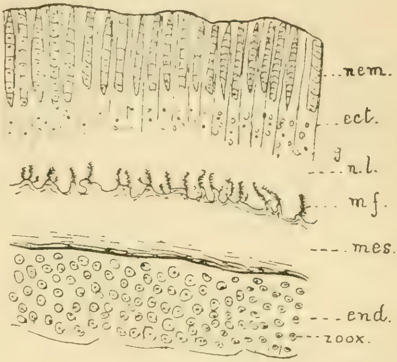
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FIG. 9.—*Anthopleura alfordi.* Transverse section of a tentacle near the base, showing a portion of the wall.

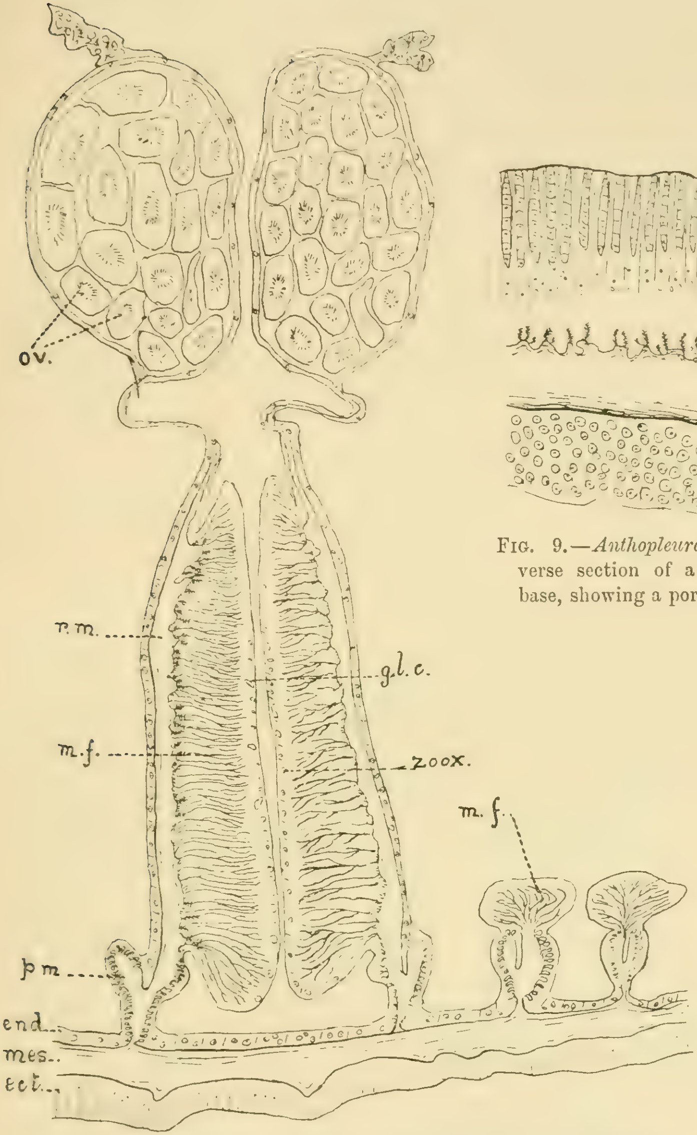
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FIG. 10.—*Anthopleura alfordi.* Transverse section through the column, showing two primary and two secondary mesenteries.

dermal muscle. The endoderm consists of a spongy layer, which is about the same thickness as the ectoderm, and this is full of colonies of zooxanthellæ. These do not stain with borax carmine, but appear as brownish granules arranged in groups.

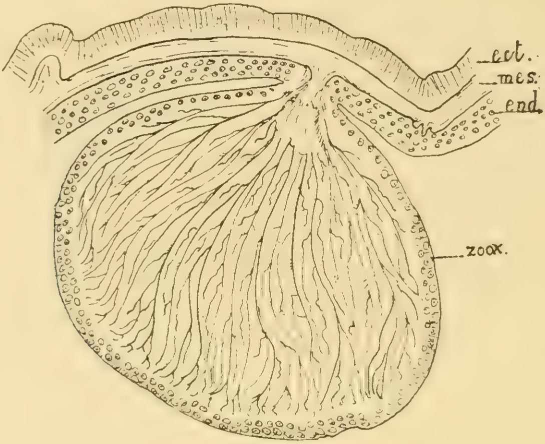

Fig. 11.—*Anthopleura alfordi*. Section through the sphincter muscle.

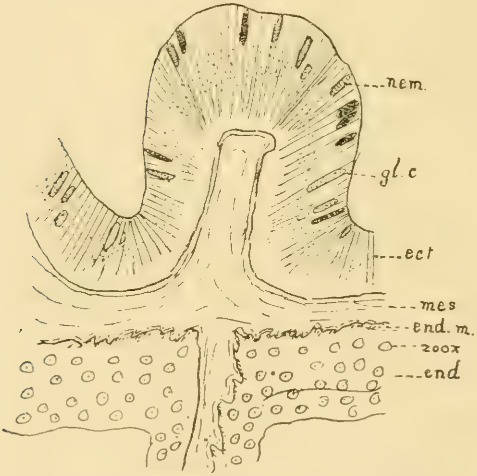

Fig. 12.—*Anthopleura alfordi*. Vertical section through the peristome wall, showing a fold, and the origin of a mesentery.

In a longitudinal section through a tentacle the ectodermal muscle can be seen as a thin plate of tissue arising from the more deeply stained mesogloea. Lobes and stunted irregular processes penetrate the endoderm. Full-sized nematocysts are situated near the outer edge of the ectoderm, while immature ones are embedded in the middle of the ectodermal tissue and are deeply stained. The older ones are longer and more transparent. The spiral thread could be faintly distinguished in one or two cases ; it is very fine and has a large number of coils. The nematocysts are more numerous at the tip, but they are well developed along the stem.

A. alfordi and *A. gelam* are alike in the following respects : they have more than six pairs of perfect mesenteries ; they possess a well-circumscribed endodermal muscle. I therefore suggest the following as an amended definition of Anthopleura : Cribrinidæ with the upper portion of the column wall provided with longitudinal rows of verrucæ, the lower portion being smooth. The margin forms a more or less distinct collar and the tentacles are polycyclic and entacmæous. More than six pairs of mesenteries of the first cycle are perfect.

Corynactis viridis (Allman, 1846).

Classification : The following is the classification adopted by Haddon :—

Tribe : Hexactiniæ (Hertwig, 1882).
Order : Stichodactylinæ (Andres).
Sub-order : Homodactylinæ (Duerden).
Family : Corallimorphidæ (Hertwig).
Genus : Corynactis (Allman).
Species : viridis.

Haddon gives the following definition of the Stichodactylinæ : " Hexactiniæ in which more than one tentacle may communicate with a mesenterial chamber. Usually a peripheral series of one or more cycles can be distinguished from an inner accessory series, the members of which are radially arranged or in groups, and are of different form. The sphincter muscle may be endodermal or absent." Branched tentacles appear quite often.

Duerden has divided the Stichodactylinæ into two sub-orders :—

(*a*) The Heterodactylinæ in which the tentacles are of two kinds, usually marginal and accessory, and separated by a bare portion of the disk, e.g. Actinotryx, Rhodactis, Heterodactyla.

(*b*) The Homodactylinæ in which the tentacles are of one kind, simple or complex, and usually follow one another in continuous rows, e.g. Richordea, Corynactis, Stoichactis.

Family : Corallimorphidæ. Stichodactylinæ with a marginal corona of tentacles, and accessory tentacles, arranged in radial series each consisting of from one to many tentacles. The muscular system is weak throughout the body.

Genus : Corynactis. Corallimorphidæ in which the body-wall is smooth. The tentacles are all knobbed and are arranged in radial series so that more than one communicates with each inter- or intra-mesenterial space. Tentacles and mesenteries tetramerous. Gonidial groove present or absent. Endodermal sphincter very weak. Mesenterial filaments devoid of ciliated streak.

Mesogloea practically homogeneous.

Corynactis viridis (Allman, 1846).

The word Corynactis (Greek=club-stick) refers to the shape of the tentacle.

The emerald-green ring round the capitulum was said to be characteristic of *C. viridis* found in European seas ; this green ring was also found on *C. carnea* (Buenos Ayres) and on *C. australis* (Port Phillip, Australia).

The specimens I examined were obtained from Plymouth, and were collected on the Breakwater. Some were brightly coloured, green and yellow, others were almost colourless. The following measurements were taken from a preserved specimen from Plymouth :—

Diameter of pedal disk=5 mm.
,, ,, column =2·5 mm.
,, ,, oral disk =4 mm.
Length of column =5·5 mm.
,, ,, tentacle =1 mm.

The external appearance of *C. viridis* has been described by many of the older writers. In 1884 Andres describes it in *L'Attinie* in page 266. In the report on Actiniaria dredged by H.M.S. *Challenger*, 1873–76, Hertwig gives the arrangement of the mesenteries. The first account was written by Allman in the *Annals and Magazine of Natural History* in 1846. Allman obtained his specimens near low-water mark in the pools left by the retiring tide in Crook Haven, Co. Cork. One of his specimens was a fairly large one measuring ·5 inch across the tentacular disk.

In Allman's specimen the colour of the tentacular disk was bright green, except for a circle of radiating brown striæ which surrounded the mouth at a short distance from its margin. The stems of the tentacles were of a sienna colour and their extremities were of a bright rose. He found varieties which were not uncommon, in which the green colour except in a narrow ring at the upper margin of the body was entirely replaced by a light flesh colour. Andres' specimen possessed a brilliant metallic iridescence.

In all the paler varieties the animal becomes translucent when expanded, so that the septa and vermiform filaments may be seen through the body-wall. This is evidently an example of albinism. The animal changes its form very often, at one time it will assume the appearance of a slender cylindrical stem, fixed by one extremity and bearing on the other extremity a flattened disk. Sometimes a contraction will take place in the middle of the body so as to cause the animal to present somewhat the appearance of an hour-glass. In assuming its many different forms the stomatodaeum is never everted.

Allman found two concentric rows of tentacles arising near the margin of the disk, but the number and arrangement is variable. They are tubular like the tentacles of other Actiniæ and communicate freely with the interseptal spaces. They are imperforate at the apices, which are very much swollen.

I have examined specimens of *C. viridis* chiefly with the aim of comparing it anatomically with the Australian specimens, which are the only Corynactids well known in this respect.

Anatomy and Histology :—

The ectoderm of the column wall is fairly spongy in places, in other places it is like that of *C. myrcia*, described by Duerden, and consists of large unicellular gland cells mingled with narrow supporting cells. The gland cells become swollen near the free surface, where in places they give rise to a clear zone. The contents of these cells are usually clear, and then they do not take stain easily but stand out as highly refractive bodies. In other cases they become deeply stained because the contents are granular.

The nuclei of the ectoderm cells are deeply stained, and as in *C. hoplites* and *C. myrcia* they are arranged in a zone a little within the middle of the ectoderm layer.

The interior part of the layer forms a clear zone, this marks the position of part of the nervous system. The ectodermal muscle can be distinguished at the base of the ectoderm. The body-wall of the pedal disk is fully expanded, and therefore appears very narrow as compared with that of the column. The ectoderm of the base appears to be one-fourth of the thickness of that of the column wall. In this region the ectodermal muscle is very strong and thick processes of mesogloea can be seen projecting into the ectoderm. A layer of foreign material is attached to the outer region of the ectoderm. The mesogloea is a very thin layer, being only one-quarter the thickness of the ectoderm. It becomes deeply stained, is homogeneous, showing no fibrillar structure ; and is thicker in places owing to the contraction of the body-wall. In structure it appears to resemble *C. hoplites* and *C. myrcia*, but in *C. hoplites* it is about the same average thickness as the ectoderm. The mesogloea of *C. australis* is also of considerable thickness.

The endoderm of the column is much narrower than the ectoderm. In this *C. viridis* differs from *C. myrcia*, where endoderm and ectoderm are of about the same thickness. In *C. viridis* the endoderm becomes thicker near the base. It consists of a spongy mass, and is not so deeply stained on the whole as the ectoderm. In some places there are large oval gland cells which contain a granular substance, these seem to be more numerous in the endoderm than in the ectoderm. The endodermal muscle is very feebly developed, but appears stronger in the base.

There are no zooxanthellæ present in this anemone, nor has their presence been indicated in any of the other members of this genus.

The sphincter muscle (Fig. 13) is endodermal, intermediate between a diffuse and a restricted form, and is stronger than that of either *C. australis* or *C. myrcia*. The mesogloeal processes are longer than those of *C. myrcia* and are slightly branched. The muscle becomes much stronger towards the upper part of the body. I have failed to recognise the simple circumscribed endodermal portion of the upper part of the sphincter as described and figured by Haddon.

The tentacles were described by Allman in 1846, and he was able to recognise two kinds of nematocysts, the small oval nematocysts which are very numerous and the large stinging cysts. Both kinds have also been found in *C. myrcia*. The structure of the tentacle (Fig. 15) is very much like that of *C. myrcia ;* the knobs consist almost wholly of deep ectoderm ; the mesogloea and endoderm are very thin, and the ectoderm consists of a mass of nematocysts, which are long oval cells with the internal spiral coil showing perfectly. These nematocysts did not stain, but appeared as highly refractive bodies and are also present along the stems of the tentacles and in the ectoderm around the mouth. In *C. myrcia* the stems of the tentacles are devoid of nematocysts, but they are found in the endoderm near the tip of the tentacles in *C. viridis ;* they have not been mentioned as occurring in the endoderm of any of the other members of this genus. There is a distinct nerve layer at the base of the ectoderm, and that of the stem contains nematocysts, but they are not so numerous as on the tip. The nematocysts in the endoderm are not so numerous as those in the ectoderm, and none are present in the endoderm near the base of the tentacle. They are also present in the oval swelling at the tip of the mesenterial filaments. The stomatodaeum is oval in section and the wall is thrown into numerous deep and regular longitudinal folds. As in *C. myrcia*, these folds show a rough approximation to the points of attachment of the complete mesenteries. The ectoderm contains a large number of gland cells, and near the base of this layer there is a quantity of granular material. The mesogloea is thin except at the summit of the folds, where it is thick and gives off small branches which form a strong ectodermal muscle. The endoderm is spongy as in the column wall, it is thicker than the mesogloea and contains large gland cells. One gonidial groove is present, which is not very deep.

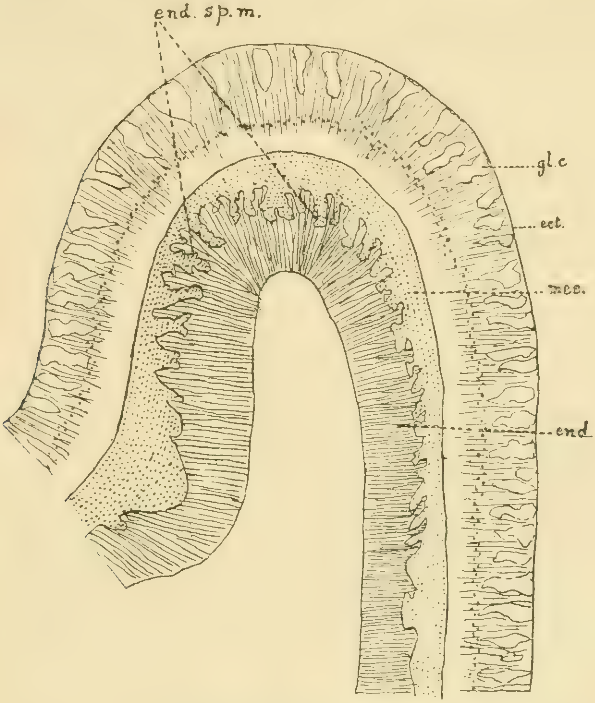

Fig. 13.—*Corynactis viridis.* Vertical section through the body-wall, showing the sphincter muscle.

The number and arrangement of the mesenteries vary in different specimens. Transverse sections of three different specimens were cut. In one there are 48 mesenteries, some complete and some incomplete, including two pairs of directives ; in another there are 36 mesenteries, including one pair of directives ; and in a third there are 46 mesenteries, including two pairs of directives.

There are two cycles of mesenteries (Fig. 14), a primary series, consisting of complete ones, and a secondary series in which they are incomplete. The incomplete mesenteries project for some distance into the cœlenteron ; in section they are nearly as broad as the primary mesenteries. The parieto-basilar muscle is stronger than that represented in the figure of *C. myrcia* and passes gradually into the retractor muscles. There is a constriction of the mesogloea at the point where it passes from the mesentery into the body-wall. The folds of the retractor muscles are more numerous than those of *C. myrcia*, and consist of a number of unbranched club-shaped processes which project into the endoderm.

A serial summary is appended showing anatomical characters of the various species of Corynactis in so far as these data have been obtainable. The ordering of tentacles and mesenteries, though frequently tetramerous, appears to be highly variable, and, pending further study, these features are omitted from the present summary.

Corynactis viridis, Allman, 1846 (British).
Sphincter (endodermal in all species) feeble and diffuse in the lower part, stronger above, mesogloeal processes branched.
Mesogloea thin.
One œsophageal groove.

C. myrcia, Duchassaing et Michelotti, 1866 (Jamaica). Anatomical data from Duerden.
Sphincter as in *C. viridis*, but weaker, mesogloeal processes unbranched.
Mesogloea thicker than the ectoderm. Endoderm thicker than in *C. viridis*.
No œsophageal groove.

C. carnea, Studer, 1878 (Buenos Ayres). Anatomical data from Kwietniewski [23]. Sphincter strong, fibres long and branching ; mesogloeal processes branched. Mesogloea about as thick as ectoderm, sometimes thicker.
Two pairs of directives, grooves weak.

C. hoplites, Haddon and Shackleton, 1896 (Torres Straits). Anatomical data from Haddon.
Sphincter strong but diffuse. Mesogloeal processes slightly branched.
Mesogloea about as thick as the ectoderm.
Two pairs of directives and one groove.

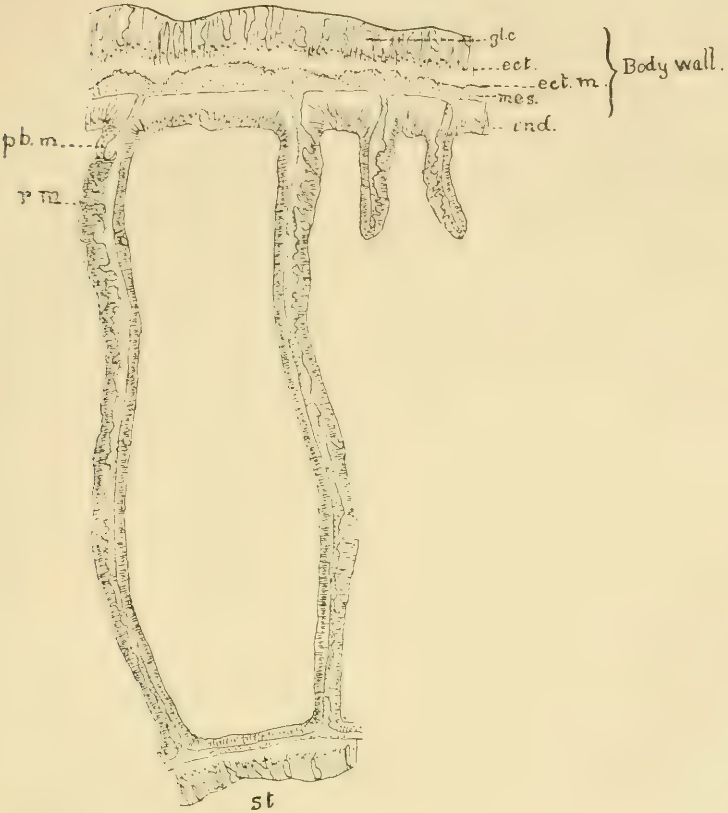
glc
ect.
ect. m.
mes.
end.
Body wall.
pb. m.
r m.
st

Fig. 14.—*Corynactis viridis.* Portion of a transverse section of the column in the region of the stomatodaeum, showing one pair of directives and one pair of incomplete mesenteries.

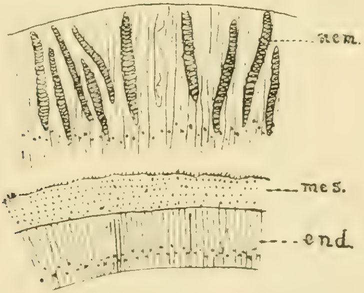

Fig. 15.—*Corynactis viridis.* Portion of a transverse section of a tentacle, showing the spiral coil in the nematocysts.

C. australis, Haddon and Duerden, 1896 (Australia). Anatomical data from Haddon and Duerden.
Sphincter weak ; mesogloeal processes barely branched.
Parieto-basilar muscle very strong.
Mesogloea thicker than ectoderm above, thins downwards.
No distinct grooves.

C. Haddoni, Farquhar, 1898.

C. gracilis, Farquhar, 1898.

C. mollis, Farquhar, 1898.

C. albida, Stuckey, 1909. Stuckey thinks all four may be varieties of one species. Occur in New Zealand. The sphincter is practically absent.

C. globulifera, Ehrenberg, 1834.
C. Hertwigi, Haddon, 1893.
C. annulata, Verril, 1869.
} These species do not appear to have been studied anatomically.

Aureliania regalis (Andres).

Sub-Family. AURELIANIDÆ.

The following is the definition adopted by Dr. F. Pax in Kükenthal, *Handbuch der Zoologie* :—

" Basilar muscle, ciliated bands, one siphonoglyphe, very strong circumscribed sphincter, longitudinal muscle of septa also very strong. Simple and branched tentacles, in some cases placed on projections of the surface of the mouth disk. Two or more tentacles communicate with each exocoel."

Andres' definition is formed from external characters. " Base adhering, column obconical, not tuberculate, imperforate. Tentacles arranged in radial series, numerous and detached, not simple, but swollen at the apices ; the knobs usually spherical, sometimes giving rise to buds. Colour yellowish red. Found in sand and on rocks."

The Genus, AURELIANIA.

" Form : Base adhering, wide. Column abconical with minute suckers secreting a membranous investment. Tentacles numerous, arranged in radial series of two tentacles each, and at the same time forming four circular cycles. Each of the cycles has a different number of tentacles. The form of the tentacle is tubercular, swollen at the apex, bilobed. Peristome convex, radially grooved. Colours yellowish orange, tinged with vermilion." The above is a translation of the description of the genus Aureliania given by Andres in *L'Attinie.* He regards two species as belonging to this genus, namely *A. heterocera* and *A. regalis*. *A. regalis* and *A. augusta*, Gosse 1860 and Andres 1880, are given as synonyms. Andres in a note states that he found the number of tentacles to agree with that in Gosse's specimen. Since colour is too unreliable a character on which to base species and since the comparative anatomy of *A. augusta*, *A. regalis*, and *A. heterocera* still remains apparently unknown, it seems necessary to retain the name *regalis* (Andres) for the present, at the same time keeping in mind the possibility of this name being merely a synonym of *A. augusta* (Gosse). The name *regalis* is used in France, from which coast the specimen referred to here was obtained. Figs. 4, 5 and 6, in Plate X in *L'Attinie*, give an exact reproduction of the form and colour of the specimen when alive.

The following is a translation of Andres' description :—

"Form : Base adhering ; spreading, irregular. Column conical below, cylindrical above, smooth, fleshy, not greatly extensible, secreting abundant mucus to form a sheath. Margin turning upwards, minutely crenate, collar deeply grooved. Disk small, smooth. Tentacles retractile, numerous (144) in four cycles (36+36+36+36). [The tentacles may be more than 144 in number ; in one specimen I found 168 (42+42+42+42) as in *A. augusta* (Gosse).] Each tentacle is short, moniliform and directed outwards. They occupy more than half the periphery of the disk. The form, "monile" (resembling a necklace), is modified in the tentacles of the two external cycles, the swellings are unequal, the proximal is rounded and the apical is prolonged to a point. The peristome is smooth, scarcely striated at the radii. Mouth round, small, not prominent.

"Colour pale rose. Column orange-vermilion with whitish specks. Tentacles of indefinite yellowish colour, transparent with opaque stains and spots. Peristome reddish vermilion. Of the gonidial radii only one is indicated, and this has a whitish line where the radius touches the periphery. Situation in the sand usually covered as far as the disk, but sometimes protruding with part of the column."

Andres examined three individuals, two coincided with the above description, but the third had the peristome spotted.

I took the following measurements from the preserved specimen :—

Diameter of base=17 mm.
Height of column=18 mm.
Diameter of oval disk greatly contracted=9 mm.

The specimen contained a large amount of mucus, this caused the tissues to contract and become very hard in xylol. The specimen had become very much contracted; for these reasons I am unable to give a full description of the species. The mesenteries are arranged in two cycles, 36+36=72. The incomplete mesenteries are unevenly developed, some appear as slight projections into the cœlenteron, others are larger and have produced many muscle folds.

The mesenteries (Fig. 16) possess a very long retractor muscle with a large number of short folds. The curious fact about this muscle is that it faces the intramesenterial space or exocoele instead of the intermesenterial space or endocoele, as is commonly found in Actinians. The longitudinal muscle of the directives faces the intermesenterial space. Near the proximial end of the mesentery lies the parieto-basilar muscle, which arises as a stout projection on the side away from the retractor muscle. It gives off a large number of folds which are longer than those of the retractor muscle, they have a somewhat reticulate appearance when examined under the high power of the microscope. The mesogloea is fibrous and has a number of cavities of irregular shapes. The wall of the œsophagus is raised into a number of lobes. There is one œsophageal groove corresponding to the pair of directive mesenteries present.

The body-wall is strong, the mesogloea forming a thicker layer than the ectoderm. The latter is raised into a large number of folds, each being supported by a process of mesogloea.

This species is extremely rare, and British specimens were not available. One specimen of *Aureliania regalis* was, however, most kindly sent by Monsieur Louis Fage from the laboratory at Banyuls-sur-Mer, and it is this specimen which has been anatomised and is described above.

INDEX TO LETTERING.

ect., ectoderm.
ect. m., ectodermal muscle.
end., endoderm.
end. m., endodermal muscle.
end. sp. m., endodermal sphincter muscle.
g., granules.
gl. c., gland cell.
mes., mesogloea.
mu., mucus.
n.l., nerve layer.
nem., nematocyst.
pb. m., parieto-basilar muscle.
r.m., retractor muscle.
sph., sphincter.
zoox., zooxanthellæ.

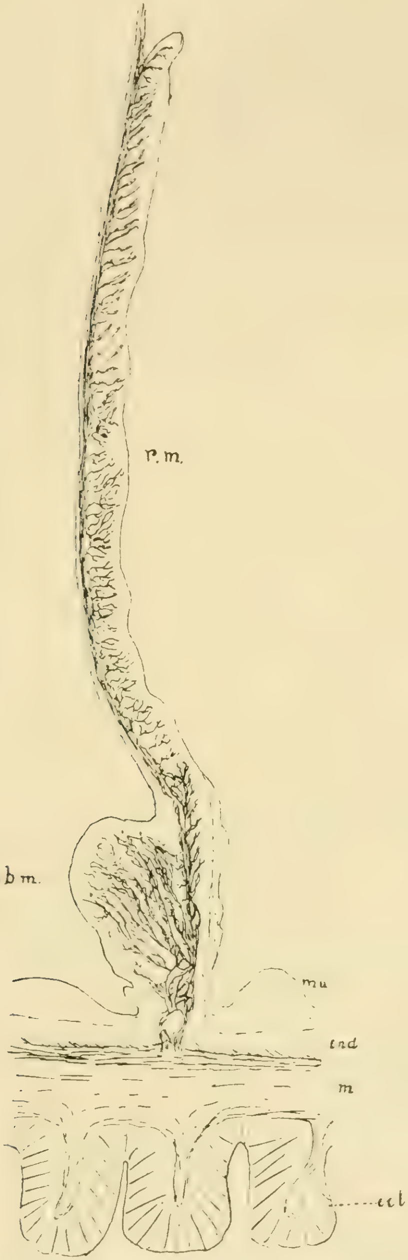

FIG. 16.—*Aureliania regalis.* Transverse section of the column, showing a portion of one of the mesenteries.

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Notes on Experiments in the Keeping of Plankton Animals under Artificial Conditions.

By

L. R. Crawshay, M.A.

TABLE OF CONTENTS.

PAGE
Introduction 555
The experiments 559
  Results obtained in Positions A and B . . . . ,,
    Zoaeae . . . . ,,
    Calanus finmarchicus . . . . ,,
    Temora longicornis 560
    Anomalocera Patersoni 561
    Acartia sp. . . . . ,,
    Young Calanoids . . . . ,,
    General 562
    Special experiment in Position A . . . . ,,
  Results obtained in Position C 563
    Pseudocalanus elongatus 564
    Calanus finmarchicus 565
    Acartia sp. 566
A comparison of C results with A and B results . . . . . . ,,
General remarks 568
On Diatom growth in the experiments 570
The influence of some Bacteria on the experiments, and their destruction . . 572

Introduction.

THE experiments referred to in the following pages were carried out by the wish of the Director at the Plymouth Laboratory, between June, 1912, and February, 1913. They were undertaken with a view to keeping under observation some of the smaller zooplankton, and particularly the Copepoda, in order that they might be followed through the different stages of their life cycle. After a long series of disappointing results, the experiments were unavoidably interrupted at a time when apparently the chief obstacles to success had been located and largely overcome.

Continued observation of these small animals has only in the last few years been rendered certainly possible by the work of Dr. Allen on the culture of the marine Diatoms, which form the chief food supply of the great majority of them, and it is not surprising that until the problem of obtaining and keeping a suitable food culture was settled, attempts to keep

Copepoda alive in the Laboratory met with little success. Mention may here be made of one important result obtained by Dr. Allen himself, in the course of his Diatom experiments. In a flask of 1000 c.c. in capacity he kept, between August and September, 1905, some specimens of *Calanus finmarchicus* alive on a mixed Diatom culture for a period of about seven weeks, and obtained from them many nauplii, two of which developed into young *Calanus*, of which the exact life period was not recorded.* It was uncertain how far the exact conditions under which this experiment was carried out had been essential to its success, and with a view to locating harmful influences and removing them as they became apparent, the experiments came to be conducted under many different conditions in regard to position in the Laboratory, the kind of vessel employed and its capacity, the water used, the intensity of the light, the food culture, and the presence or absence of an air supply. Attention was also given to the question of the influence of some of the Bacteria and their destruction. Only after a large number of experiments had been made was it ascertained that due consideration had not been given to a factor, the importance of which cannot be overestimated, namely, temperature, and that to irregularities of temperature the repeated failure of the earlier experiments was without doubt to be attributed in a very large degree. The work which has since been resumed still needs careful attention to details of method before satisfactory results can be obtained, and in the meantime a short account of the experiments is given as a preliminary contribution to the subject.

The experiments will be considered, as far as may be, in the order in which they were carried out, while grouping them together according to different conditions, some reference to which is first necessary.

Position.

(A) In this room, where most of the earlier experiments were made, the aspect is north and the light moderate. The window was at all times kept partly open, and no artificial heating was used ; consequently the experiments were very susceptible to outside changes of temperature that occurred from one day to another. Records of the temperature of the water of the experiments were not made till the latter part of November, but twenty-five observations made between November 26th and January 13th showed a varying range of 6° or more,† a maximum daily variation of 3·8°, and a maximum change over two days of 5·8°, the average temperature being 10·8°. During the summer months, the changes must have been very much greater.

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* *Journ. Mar. Biol. Assoc.*, N.S., Vol. VIII., p. 470.

† All temperatures are recorded in degrees Centigrade.

(B) Here the vessels rested on a table close to a large double window, with a western aspect, partly lighted also from the northern side, and the light was consequently good. The position in the building being more central than Position A, the changes in temperature were probably, on the whole, less in extent and less sudden than in the latter. At times, however, they were greater, as, for example, in the month of July, when on four successive days the following temperatures of water in the bell-jars were recorded : July 17th, 25° ; July 18th, 20° ; July 19th, 16·3° ; July 20th, 17°.

(C) In this part of the building, the General Laboratory, well lighted with large windows, both on the southern and on the northern sides, the light obtained was always good, and often so strong as to need screening. In the colder weather the air temperature is kept by hot-water pipes between 13° and 18°, and in general it is subject to very much less change than in either of the other two positions. As, however, in all experiments here carried out, the vessels were kept submerged, either in the sea-water of the general circulation or in water artificially adjusted to a nearly constant temperature, the changes in air temperature were of minor importance and, as affecting the experiments, almost negligible. The water of the experiments, which was necessarily regulated by the temperature of the tank water, showed over a number of observations made between November 26th and February 7th a varying range of no more than 1·6°, a maximum daily variation of 1°, and an average temperature of 12·3°.

Vessels.

These consisted chiefly of the following :—

Glass Finger-bowls.	Capacity, 350 c.c.
,, Flasks.	,, 1 and 1·5 litres.
,, Jars.	,, 2 litres.
,, Beakers.	,, 2 ,,
,, Bell-jars.	,, 11 ,,

The vessels were covered with squares of glass or with watch glasses, as a provision against dust. Except in one special experiment (p. 562), there was no circulation of water through the vessels, the water being left standing, subject only to stirring by aeration or otherwise, and being only changed in certain occasional instances.

Water.

(A) Tank Water.—Water circulated through the tanks of the Laboratory from the supply stored in the reservoirs. This water is pumped up into the reservoirs from the sea below the Laboratory at high water spring tides. In consequence of the large number of animals living in the tanks it contains a considerable amount of excretory products.

(B) Berkefeld Water.—Tank water treated with animal charcoal, and filtered through a Berkefeld candle. In many experiments, owing to the high salinity of the tank water, this was diluted with 5% distilled water.

(C) " Outside " Water.—Water brought in from outside the Plymouth Breakwater, and largely free from the contamination of the inshore grounds. This was used sometimes untreated, sometimes sterilised, and sometimes filtered through a Berkefeld candle.

(D) Miquel Sea-Water.—Occasionally Berkefeld, usually " outside " water, treated with the modified Miquel solution employed by Allen and Nelson,* but chiefly used in considerably less strength, generally one-third, in experiments here to be considered.

Light.

Additional illumination was obtained when necessary by placing sheets of white paper or card, or of opal glass, under the vessels, and in many cases behind them also. In some experiments the light was partially or wholly cut off by screening the vessels with black paper.

Food.

In most of the experiments a culture of the Diatom *Nitzschia closterium* was used as food for the animals. In some, the Alga *Chlorodendron subsalsum* was used.

Air-supply.

Artificial aeration of the water was employed at intervals in many of the experiments for varying periods, and sometimes continuously, by means of drawn-out glass tubes led into the vessels, and connected with the general air-pressure system of the Laboratory. It may be said at once that no definite advantage seemed to be gained by its use, assuming the water to be naturally aerated at the outset.

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* *Journ. Mar. Biol. Assoc.*, N.S., Vol. VIII., p. 428.

The Experiments.

For brevity, the results of the experiments will be considered in a summarised form, the experiments being grouped together according to the vessels in which they were carried out. The recorded averages and maxima refer to the life period in days occurring among animals of the several experiments in each group. The experiments carried out in Positions A and B, in all of which the vessels were exposed to the influence of air temperature changes, will first be dealt with. Later, the experiments in Position C, in all of which the vessels were submerged, will be treated in the same manner, and the results of these will then be compared with those in Positions A and B. The dates given are those on which the different experiments were started.

POSITIONS A AND B.

In the experiments to be referred to, all but those made in 11-litre bell-jars were carried out in Position A. The results are marked with great irregularity. In certain exceptional cases, specimens lived for a considerable period, but the averages are almost consistently low, and it is evident that some factor entered into all the experiments which rendered the conditions unsuitable and in most cases quite intolerable. In some preliminary experiments in tank water, to which no *Nitzschia* or other food was added, rather lower averages occurred, but in other respects no distinct advantage was traceable to the kind of water used, which included Berkefeld, Berkefeld diluted, the same with Miquel-Allen solution in full proportions, " outside " water untreated, and the same sterilised. Some species appear to be more delicate than others, and among nauplii the mortality was exceptionally high. The different forms will, therefore, be considered separately.

Zoaeae. These should perhaps be viewed in a different category from the rest, since it is doubtful whether a suitable food was found for them, though *Nitzschia*, *Chlorodendron*, and Ciliate cultures were tried. In a total number of 18 experiments with from 4 to 11 specimens, in finger-bowls (June 11th to July 30th), the average time of survival was from 5 to 7 days, the maximum ranging from 11 to 16 days.

Calanus finmarchicus. In finger-bowls, 5 experiments comprising from 5 to 12 specimens (June 19th to August 7th) showed in Berkefeld, Berkefeld diluted, and Berkefeld diluted plus Miquel-Allen solution, comparatively little difference of average, 11 to 14 days, from that of 3 experiments in tank water (10 days), to which no *Nitzschia* or other food was added. Apart from one exceptional example in which a specimen, infected with the parasite *Microniscus*, lived for 40 days, the maximum was no higher than 23 days, which was 4 days in excess of the next highest period.

In 1-litre flasks, 5 experiments in " outside " water, containing from 3 to 5 specimens (September 27th to October 23rd) showed a higher average, of about 22 days, than was obtained in the finger-bowls, and a much higher maximum of 84 days. In the experiment in which this high maximum occurred (October 21st) the shortest life period was 23 days, and the average for the three individuals was about 44 days. No clear explanation was found for the fact that in three other *Calanus* experiments, started two days later under almost identically similar conditions, the maximum was no higher than 27 days, and the average about 16 days.

Temora longicornis. In finger-bowls, 9 experiments with from 6 to 12 specimens (June 19th to August 8th) were far less successful than in the case of *Calanus*, and a maximum of 23 days, which was obtained in one case in Berkefeld water, was far in excess of the life period that was usually sustained. The data for averages are incomplete, but with the exception mentioned the longest life did not exceed 11 days, and the average for all the experiments was probably not above 5 days.

In 1-litre flasks, 2 experiments, with 7 and 10 specimens, in sterilised " outside " water (September 18th and 27th), were little more successful than those in the finger-bowls, the maximum being about 17 days, and the average life probably not exceeding 5 or 6 days. In connection with the mortality of this species, it is very remarkable that in the first of these two experiments, 6 *Acartia* which were included in the same vessel at the same time subsequently reached the high average of about 60 days.

In 11-litre bell-jars (Position B), an experiment with 70 specimens, in Berkefeld water (July 17th) failed completely, all dying within two days. Of a similar number, placed in the same bell-jar with the same water (July 19th), none lived for more than about a fortnight. In an experiment with 50 specimens in " outside " water (July 17th), a few only survived the first fortnight, though a single specimen lived for 48 days. Mention has already been made (p. 557) of the irregular and high temperatures that were recorded for the water in bell-jars in this position at this period, showing over four successive days a range of nearly 9°, with a maximum daily variation of 5°, and these irregularities were with little doubt accountable for the mortality of specimens, even in so large a volume of water.

Anomalocera Patersoni. In finger-bowls, 2 experiments with 6 and 3 specimens, were made in tank water only, to which no *Nitzschia* or other food was added (June 10th). These 9 specimens showed an average of 2 days only, the maximum being 4 days.

Acartia sp. In a 1-litre flask, a single experiment with 6 specimens in sterilised "outside" water (September 18th) showed the high maximum of 100 days, the average being about 60 days. This was the only experiment carried out in Position A in which nauplii were certainly produced, a few of these being observed continuously from the 30th to the 73rd days. The number of nauplii produced, and their individual life periods are uncertain. No more than four were recorded at any one time. Some showed distinct growth, but none reached an advanced stage. As it has been stated, 7 *Temora* which were included with these *Acartia*, all died within about 17 days, and it would seem on the evidence of this single experiment that the species (probably *A. Clausi*) is more hardy than *Calanus* or *Temora*. The experiment lasted till December 27th.

Nauplii (chiefly *Balanus*, *Temora*, and *Calanus*). In finger-bowls, 3 experiments with from 15 to 20 specimens in Berkefeld water (July 11th) showed a maximum of 4 days ; in 3 experiments, with from 20 to 100 specimens, in Berkefeld diluted (July 19th to 30th), the maximum was about 15 days ; in 2 experiments, each with 20 specimens, in Berkefeld diluted, plus Miquel-Allen solution (August 8th), the maximum was about 12 days. The average for all these experiments probably did not exceed 2 days. On the other hand, as it has been shown, among the *Acartia* nauplii hatched from eggs laid in the vessel, some appear to have lived for a considerable time though the individual life periods were not known.

Young Calanoids. In 1-litre flasks with several young forms naturally contained in this bulk of "outside" water, and with no additional food included, 2 experiments (September 24th) showed a maximum life period of 18 days only.

In a bell-jar (Position B) an experiment in Berkefeld water with mixed plankton including many young forms, and with some fine tow-netting added as food (June 10th), showed several young forms, including nauplii, alive and healthy on the 33rd day, and a few continued till the 42nd day. Soon after this all disappeared, the specimens apparently failing, like others previously referred to, in consequence of high and irregular temperatures at the time in this position.

General. As bearing on the sensitiveness of some Calanoids to sudden changes in the water conditions, the following example is important. On June 15th, two *Calanus finmarchicus* were given to me by Mr. Fuchs in a large jar (breffit) of 2000 c.c. in capacity, in " outside " water containing a growth of *Nitzschia*, in which he had reared some Echinoplutei. The culture had been started by him on April 19th, and kept from that date on one of the slate slabs in the General Laboratory. In the water that was used the two *Calanus* had been introduced unobserved, evidently as young forms, possibly as nauplii, and these, feeding on the *Nitzschia* culture, had grown to nearly full size. On June 15th the jar was taken over by me and placed in Position A, where the *Calanus* continued healthy until July 9th. The *Nitzschia* having then grown too thick the *Calanus* were transferred to a new culture in Berkefeld water, in a clean jar. One specimen was stunned by the change, and fell to the bottom, remaining almost motionless afterwards, and both died within two days. The temperatures had been taken, and Mr. Matthews having kindly analysed samples of the water and ascertained the densities, the change of conditions from one jar to the other proved to have been as follows :—

		T.	S.%	σ_t
Jar A.	" Outside " water	16·5	35·22	25·82
Jar B.	Berkefeld ,,	17·5	37·94	27·68

The temperature change being one of only 1°, it seemed evident that the death of these *Calanus* was to be attributed to a sudden change of 2·72 in salinity, and owing to this the Berkefeld water subsequently used in the experiments was diluted with 5% distilled water. It was thought that by thus obviating such sudden changes in salinity, much of the difficulty previously encountered in the experiments might be overcome. It was not realised till later that repeated changes in the air temperature communicating themselves less suddenly to the water in the exposed vessels might be equally harmful in their effects.

Special Experiment in Position A.

In the latter part of the year, it became increasingly evident that some factor which had escaped observation was a constant source of harm to the animals. In view of the possibility that this might be the presence of Bacteria, several experiments, which will be referred to in detail later, had been made in keeping Copepoda in the presence of strong cultures of Bacteria raised on peptone. But the results of these experiments showed that species were capable of tolerating such conditions to a much greater degree than was expected, and did not bear out the supposition that bacterial infection had been the primary cause of failure. Experiments also made with and without an air-supply gave no definite evidence of the value of an air-supply as improving the conditions in water that was naturally aerated at the outset.

There remained a possibility that harmful conditions might be produced through the accumulation of excretory products in the vessels, and to test this a special experiment in Position A was arranged, by which a constantly changing supply of water and food was passed through the vessel in which the animals were contained. For this purpose a large bottle, of 10 litres in capacity, was filled with sterilised "outside" water, with Miquel-Allen solution in proportions one-third of those used by Allen and Nelson, and this water was infected with a culture of *Nitzschia*. The vessel of the experiment, in which 5 *Calanus* were placed, was a 1·5-litre flask, and into this the supply was led by a glass tube from the large bottle, the apparatus being arranged in the form of a self-regulating siphon, by which the water in the flask was kept at a constant level. From close against the bottom of the flask, a siphon tube was led out from the flask to the exterior, to serve as a waste pipe, and this, drawing on the contents of the flask, was so adjusted by a screw clip that the water and food-supply was made to pass through the flask at the rate of 1 litre per diem, nearly. An air-supply was also provided at a slow rate in the flask by connection with the air-pressure system of the Laboratory. A good light was ensured and, the food growth being strong, the conditions were such as appeared to meet all requirements. But little improvement was shown in the result of this experiment which, though more successful than most of the previous ones, produced only a maximum life of 28 days, and an average of about 21 days, the shortest life being 14 days. This experiment was started on October 16th, 5 days prior to the commencement of an experiment made in the same position, in a 1-litre flask under the ordinary conditions, in which 3 *Calanus* subsequently showed a maximum of 84 days, and an average of 44 days (p. 560).

POSITION C.

It had in the meantime been observed that a *Calanus* which had been left in a 2000 c.c. jar, partly submerged in one of the tanks in the General Laboratory on August 28th, was still alive on October 18th, 51 days later, and, soon after the close of the special experiment just described, a new series was started with the vessels submerged up to the neck in the same manner. An improvement in the results soon became apparent, and from this time the experiments were continued under these altered conditions, either in one of the tanks or in a small extemporised reservoir of water.

In the first experiment, with 6 *Temora*, in a 2-litre jar of water, with *Chlorodendron* as food, one specimen only was alive on the 19th day, and this did not live for more than a few days afterwards. These *Temora*, however, had been left standing for 7 days previously, in a beaker in Position A before the experiment was started, and the result was therefore of doubtful value.

The other experiments related chiefly to *Pseudocalanus elongatus* and *Calanus finmarchicus.* The water used was in all cases "outside" water, treated with one-third Miquel-Allen solution and filtered through a Berkefeld filter. In the majority of the experiments the food was *Nitzschia ;* in a few cases *Chlorodendron* was used. Exact data for averages are wanting, and the results can only be considered in their main details. In many cases the observations were unfortunately interrupted before the complete records had been obtained. The results may be summarised as follows :—

Pseudocalanus elongatus. In 2-litre beakers, 3 experiments, each with 15 specimens (November 11th to 28th), showed on the 44th, 50th, and 51st days, severally, about 23 survivors. In one of these experiments, the water having been changed on the 44th day, four were still living on the 72nd day. In another a change of water on the 51st day led to bacterial infection, with fatal results to all the specimens very soon afterwards. In the third, one specimen was still living on the 121st day.

In an uncompleted experiment with 20 specimens (December 20th) a few were still living on the 50th day.

Two experiments (Nos. 174 and 175), which failed through injury caused in connection with an air-supply, are referred to below.

Nauplii were obtained in all the experiments with *Pseudocalanus*, their presence and growth being observed over periods which varied from 40 to 63 days in the different experiments, omitting the two experiments last referred to. Data concerning individual life periods are not available, but several were recorded as reaching the adult form and, in a few cases, apparently the full growth, the age at which the adult stage was reached being approximately between 35 and 40 days.

In the experiment in which the loss of the specimens was attributed to bacterial infection, bright carmine patches appeared colouring the dead bodies of the specimens, other objects at the bottom of the vessel being suffused with the same colour. Mr. Harold Drew kindly tried to cultivate the Bacteria on peptone agar, but no growth was obtained.

The circumstances of the failure of the two experiments (November 30th) in connection with the use of an air-supply are as follows :—

Each experiment concerned 20 specimens.

(No. 174.) Till the 14th day, several were seen very active, and on this day from 20 to 30 nauplii were observed. On the 15th day, all the nauplii and nearly all the adults were dead. On the 19th day, only one of the adults remained alive, showing little movement, on the bottom of the vessel.

(No. 175.) On the 14th day, about a dozen adults and a few nauplii were seen. No subsequent records were made till the 19th day, when nearly all were dead. On the following day a few nauplii still survived, but these died soon afterwards.

In these two experiments the vessels had been provided with an air jet, forced through the water by connection with the air-pressure system of the Laboratory, during the 24 hours between the 13th and 14th days. When on the 14th day the air-supply was taken off, and the vessels removed from the tank for examination, they remained exposed for about half an hour to the much higher air temperature of the Laboratory. The rise in the temperature of the water thus caused was not observed, but it seems possible that the air-saturated water of the vessels thus parting rapidly with air in solution, injury was caused to the blood system of the animals.

Calanus finmarchicus. In 2-litre beakers, submerged in the tank, 5 experiments (November 30th to January 13th) resulted, as far as the observations were carried, as follows :—

Experiments.	Specimens.	Max. Period of Life Recorded, days.	Average, days.
1	2	48	35 (completed)
1	5	27	19 ,,
1	3	64	41 (uncompleted)
2	3, 5	About 6 living on 45th day	,,

Ova were obtained in the last two experiments, but were lost through an accident.

In 1-litre flasks submerged in a bath heated over a small bunsen flame to 16°–18°, and kept by a regulating thermometer at this approximate temperature, five experiments (January 13th to 29th) showed the following results up to the time when the observations were interrupted:—

No.	Date.	Specimens.	Adults.	Remarks.
195	Jan. 13th	3	All living on 12th day (and apparently on 26th day).	Many Nauplii seen between 6th and 26th days.
198	„ 18th	3	All living on 20th day.	One Nauplius on 4th day. None seen on 20th day.
200	„ 24th	3	Two „ „ 16th day.	One egg seen on 15th day.
201	„ „	4	All dead on 5th day.	Water infected by Bacteria forming long white strands.
202	„ 29th	3	Two living on 30th day.	About 7 ova seen on 11th day.

Omitting the experiment which failed through bacterial infection, the mortality was small at the time when the observations were interrupted, two deaths only having been recorded among the twelve specimens over a period averaging at least 20 days and probably 23 days, in the different experiments.

Ova were obtained in all these experiments, and nauplii were recorded in two of them, many occurring in one over a period of 20 days.

Acartia sp.* In a 1-litre flask, submerged in the artificially heated bath, a single experiment was made (December 20th) with 5 specimens. On the 40th day three of these were living. Nauplii were first observed on the 23rd day, about a dozen were seen on the 25th and 32nd days, and a few only on the 40th day.

A Comparison of the Results obtained in Position C with those obtained in Positions A and B.

The experiments with *Pseudocalanus* having all been made in Position C, the results obtained with this species must be treated with some reserve when comparing them with those obtained for other species in Positions A and B, and it is better to consider them only as confirming the evidence of the experiments with *Calanus* and the single experiment with *Acartia*.

For *Acartia*, the only experiment in Position A gave the high maximum of 100 days, and an average of 60 days for the 6 specimens. In the uncompleted experiment in Position C, 3 out of the 5 specimens were still living on the 40th day. The combined life period of the young was in the former case 43 days, and in the latter 17 days when the last record was made. It is only noticeable that in Position C the fertility of the parents was distinctly higher than in Position A. It seems probable that the species is hardy as compared with others and less susceptible to injury from changeable conditions (cf. p. 561).

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* Probably *A. Clausi*. The species was not certainly determined.

For *Calanus*, the comparative results are as follows :—

Position A.

(1) Finger-bowls.	Max. for 5 experiments (34 specimens), 40 days.	Avg. 12 days.
(2) 1-litre flasks.	„ 5 „ (19 „), 84 „	„ 22 „
(3) Special expt.	„ 1 „ (5 „), 28 „	„ 21 „
	Average for 11 experiments,	17 „

Position C.

(1) 2-litre beakers. Max. for 2 completed exps. (7 specimens), 48 days. Avg. 27 days.
Of 3 uncompleted experiments, one with 3 specimens showed at the time of the last record an average of 41 days ; the other two, with 8 specimens, showed on the 45th day an average of 40 days.

The average for these 5 experiments then exceeded 35 days.

(2) 1-litre flasks. The 4 experiments (12 specimens) were very incomplete at the time of their interruption, only one death having occurred in each of two of them, on the 16th and 30th days respectively, or over a period averaging in the 4 experiments not less than 20 (or 23) days.

The 5th flask experiment is omitted from consideration here. The Bacteria by which the water became infected appear to be comparatively uncommon, and, if the general form of the strands produced by them can be relied on as characteristic, they were only twice observed, each time with fatal results to the animals.

Disregarding the last experiment, it may reasonably be estimated that the average for the 4 experiments with *Calanus* in 1-litre flasks would not have been *less* than that shown by the 5 others in Position C at the close of the observations, viz., 35 days.

In regard to experiments in Positions A and B generally, the early falling off of specimens is noticeable in nearly all the results, thus :—

For *Temora*, the average of 9 experiments in finger-bowls was not more than about 5 days ; that of 2 experiments in 1-litre flasks was about the same ; in 2 experiments in 11-litre bell-jars, few survived the first fortnight.

With *Anomalocera*, the 2 experiments with 9 specimens in finger-bowls showed an average of 2 days only, with a maximum of 4 days.

With *Nauplii*, especially those of *Balanus*, *Temora*, and *Calanus*, introduced direct from the townettings into finger-bowls, the mortality was very high, none living for more than about 15 days, and the average for 8 experiments probably not exceeding 2 days. The few, on the other hand, obtained in the course of the experiment with *Acartia*, lived for a considerable time. In a few experiments in Position A with mixed plankton kept in its natural proportions, in the water that contained it, from 1 to 3 nauplii were observed alive in 3 different experiments in 1-litre flasks, after 11, 11, and 17 days severally; their continuance in these cases being possibly due to the absence of the initial change of water that was made in the ordinary experiments. On more than one occasion, when nauplii were transferred from townettings to water of a different (higher) temperature, they were seen to be temporarily stunned by the change, and to fall to the bottom of the vessel, though usually recovering within some 5 or 10 minutes afterwards.

Young Calanoids generally, included with some mixed plankton in an 11-litre bell-jar of Berkefeld water in Position B, showed a comparatively high maximum in this larger volume of water, several, including nauplii, surviving on the 33rd and a few on the 42nd day.

There remain for consideration the experiments in Position C with the species *Pseudocalanus elongatus*, for which unfortunately there are no comparative data in the other positions. Of the 6 experiments which have been referred to, 2 may be omitted in which a sudden failure was attributable to the use of an air-supply. In 3 of the remaining 4 experiments, about 50% of the total number of specimens were alive on the 50th day, some being afterwards recorded considerably later; in the 4th probably 30% were alive on the 50th day. Young, which were obtained in all the experiments, were recorded in these four over periods ranging from 40 to 63 days in duration, one or more in each case reaching the adult stage.

General Remarks.

While it is not improbable that other adverse causes, in addition to that of changeable temperature, contributed in some measure to the generally unsuccessful results of experiments in Positions A and B, it is difficult to trace them with any consistency, or to attribute the failure of the animals to any single chief cause other than the fluctuations of temperature occurring in vessels which were directly exposed to air changes.

Experiments with some of the common putrefactive Bacteria, cultivated on peptone, in no way bore out a supposition that the presence of such Bacteria, and their fouling effects on the water, had exercised any important influence on the progress of the experiments. The possibility of infection by Bacteria of a different nature, such, for example, as the two forms referred to (pp. 565, 566), must of course be considered. But such forms as these were rarely observed, nor did the very irregular rate of mortality among individuals in an experiment, or in different experiments, suggest that bacterial action was primarily accountable for the death of the specimens.

Food-growth again, was in many cases poor and uncertain in experiments in Position A, but as the food-supply was with few exceptions renewed at frequent intervals, it seems unlikely that the animals were much affected by any such deficiency. It was often observed, too, that when food-growth was vigorous the animals died off independently of this, or even earlier than in experiments in which the growth was poor or stationary.

A noticeable feature occurs in connection with the special experiment in Position A (p. 562), in which, apart from temperature, apparently ideal conditions were provided, and a healthy growing food culture was carried in the changing water-supply through the vessel in which the animals were contained. This vessel was a 1·5-litre flask, and it is remarkable that the average life of the 5 *Calanus* it contained was very nearly the same, 21 days, as that for the 19 specimens of the 5 experiments with this species in 1-litre flasks in the same room, 22 days. In the 5 experiments with 34 specimens in finger-bowls, in which the volume of water was no more than 300–350 c.c., the low average of 12 days is presumably attributable to the changes communicated by the air temperature being more rapid than in the case of the larger vessels. If an instantaneous change of temperature, probably of 4° or 5° (p. 568), can so affect nauplii as to stun them for 5 or 10 minutes, or if one, apparently of salinity only, can be fatal, as in the case of the 2 *Calanus* referred to (p. 562), it is reasonable to suppose that the daily fluctuations of air temperature to which uncovered vessels are exposed are liable to produce conditions that must sooner or later prove fatal to animals so sensitive to such changes.

The removal of the experiments to Position C was especially prompted, as it was observed, by the survival of a *Calanus* for 51 days in a 2-litre jar submerged in one of the tanks. This specimen was then found to have the hairs of the antennæ and caudal rami much encrusted with fixed Diatoms and other accretion, and probably succumbed owing to these causes about a week later. This jar contained a sample of water only, with the plankton naturally present in it, and therefore very few individuals at the outset, nor was any addition made to the food. Yet on the 29th day there were seen alive in it, besides the adult *Calanus*, a few small ones, and one or two *Temora*, the latter being a species for which very low averages had been obtained elsewhere.

In the experiment carried out by Dr. Allen (p. 556), in which some *Calanus* were kept alive for not less than about 50 days, and in which two of the nauplii reached the adult stage, the flask used was kept standing in the water of one of the tanks. In the case of the 2 *Calanus* that were raised by Mr. Fuchs in an *Echinopluteus* culture, the jar containing these was not submerged, but was kept standing on one of the slate slabs under the tanks in the same room. Here these two specimens lived for 57 days, and subsequently in Position A for another 24 days, making a total period of 81 days. It is not known how far this result may have been exceptional, like such examples as that in which a specimen lived for 84 days in a 1-litre flask in Position A, but probably, under such conditions, the temperature changes in the water of a jar of 2000 c.c. would at most times be slight and gradual, and not such as seriously to affect the animals.

For the 5 experiments with *Calanus* in vessels submerged in the tanks the average, 35 days, is very incomplete, three of the experiments being uncompleted. For the 4 experiments in vessels submerged in the artificially heated bath, the low mortality at the time of their interruption suggested an average not lower than was indicated in the others, which at the close of the observations stood at rather more than double the average (17 days) obtained for the 11 experiments with this species in Position A.

As a series of preliminary experiments, the results with *Pseudocalanus* may, on the whole, be regarded as fairly satisfactory, the small proportion of nauplii which were brought through to the adult form being probably due to minor imperfections only in the conditions, possibly in the food-supply which it should not be difficult to adjust.

The results of the experiments in Position C are not as conclusive as might be wished, but their difference as a whole and in detail from the others is so marked as to leave little doubt that the preservation of an even temperature is of the first importance in experiments with pelagic Copepoda, and probably indispensable to success with the majority of pelagic plankton species.

On Diatom Growth in the Experiments.

In nearly all the experiments in Position C with *Calanus finmarchicus* considerable difficulty was encountered in controlling the growth of the food-supply (*Nitzschia*). Notes as to exact dates are incomplete, but the rapidity of growth seems to have become especially apparent during the second week, the *Nitzschia* then becoming so thick as soon afterwards to necessitate the pouring off and renewal of the water. This was very pronounced in the flasks submerged in the bath heated to about 18°. Under the latter conditions, a flask containing only *Nitzschia* was recorded on the 12th day merely as "growing well," and another which was taken over for use in an experiment on the 15th day without comment was presumably in the same condition. In all of 4 flasks, however, which contained *Calanus* at this time—3 specimens in each—the growth became very thick on the 11th or 12th day, and soon afterwards so dense that it was very difficult to discern the specimens. In the same bath with these flasks was the one containing 5 *Acartia*, in which the specimens did well and produced several nauplii, yet in this case the growth was on the 40th day so slight that the *Nitzschia* was then renewed. Similarly, in all the experiments with *Pseudocalanus* (4 with *Nitzschia*) no pronounced growth of the Diatom occurred during the long period for which this species was kept.

While this overgrowth of food in experiments with *Calanus* was a serious hindrance and probably interfered considerably with the preservation of healthy conditions, the fact has a greater importance in its bearing on Diatom growth. Further investigations are needed before any very definite conclusions can be drawn from these limited data, but the facts suggest the presence of a strong fertilising action directly or indirectly traceable to the excretory products of *Calanus finmarchicus*, which, though probably occurring also in other species, seems not to occur in *Pseudocalanus*, or, judging from one experiment, in *Acartia*.

The water used in all these experiments was "outside" water, sometimes sterilised, always with the addition of one-third Miquel-Allen solution, that is to say, in the proportions of 2 c.c. of Solution A and 1 c.c. of Solution B to 3 litres of sea-water, the water being then filtered through a Berkefeld filter. How far the action arises independently of Miquel is not yet clear. In two later experiments, each with 5 specimens, in 2 litres of unfiltered sterilised "outside" water only, a similar intense growth was obtained. In consequence of this, it was decided to suspend the use of Miquel, and using only filtered unsterilised "outside" water, to reduce the number of specimens. In experiments made under these latter conditions, with 1 or 2 *Calanus* in 2 litres of water, the growth has been more often slight or moderate, though sometimes so strong as to necessitate partial screening from the light. The intense growth obtained in one-third Miquel water occurred in experiments either with 3 *Calanus* per litre, or with from 2 to 5 *Calanus* per 2 litres. During the transition, which was a gradual one, from one-fourth Miquel to pure " outside " water, a thick growth was still obtained in an experiment with 1 *Calanus* in 2 litres, when it was estimated that a trace only of Miquel remained in the water.

The exact bearing which these facts may have on the problems of Diatom growth which are under investigation by Dr. Allen* will, it is hoped, become more apparent as the experiments are continued. That the action of the *Calanus* excreta is such as greatly to intensify the growth in the presence of the Miquel salts, even when the latter are used in much reduced proportions, there seems to be no doubt. Whether it is quite an independent one is at present somewhat uncertain.†

The Influence of some Bacteria on the Experiments, and their Destruction.

In order to ascertain the possible influence of some of the common Bacteria as contributing to the unsuccessful results of the earlier experiments, some special experiments were carried out in which Bacteria were encouraged to grow in large numbers in the water. As a food basis a stock solution of peptone, of 5 grams per litre in strength, was prepared in diluted Berkefeld water, and this was used in very small quantities.

In some peptone-agar cultures which Mr. Drew kindly made for me, from some infected water, two forms of Bacteria were obtained : one producing large spreading, roughly circular, white colonies, from 1 to 5 millimetres in diameter ; the other forming small compact, often almond-shaped, yellowish-white colonies, usually about half a millimetre in greatest measurement.

Three 1-litre flasks of diluted Berkefeld water were infected with both of these forms, peptone being added in the percentages of ·001, ·002, and ·01, severally. On the following day the water in all the flasks was clouded with Bacteria.

In the first of these experiments (·001% solution) the cloudiness continued unchanged on the 58th day. On the 68th day, it had nearly disappeared, and the peptone being then renewed in the same proportions, the bacterial growth was restored, and continued on the 90th day subsequently.

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* Cf. *Journ. Mar. Biol. Assoc.*, N.S., Vol. VIII., p. 421 ; Vol. X., p. 417.

† The most recent experiments support the view that the action is an independent one.—L. R. C.

In the second experiment (·002% solution) the cloudiness still continued on the 68th day, and the peptone being then renewed, there was no falling off in the Bacteria on the 90th day afterwards.

In the third experiment (·01% solution) the cloudiness was unchanged on the 47th day, and the water was then inoculated with 20 c.c. of a culture of a Ciliate, *Euplotes* sp. On the 9th day subsequently the water was found to be cleared of Bacteria, the *Euplotes* being present in very large numbers, but owing to my temporary absence in the interval it was not known at what period exactly the water became cleared. This experiment is of interest as exemplifying the destructive action of a Ciliate on a Bacteria culture of long standing.

In all experiments in which Bacteria were grown on peptone, or on the macerating remains of dead plankton, the same action occurred on the part of Infusoria, either naturally present or introduced into the water. Those purposely introduced were from mixed cultures only, in which one or more species were especially prominent. Such a culture was that of *Euplotes*, which was kept for a long period in a flask in Position A. Another large species, apparently a *Strombidium*, was usually obtained in large numbers in "outside" water in which Bacteria were grown, but some difficulty was encountered in retaining this indefinitely as an active culture and often, after a varying period of multiplication, it was lost sight of or died, being then usually superseded by a culture of smaller forms.

Experiments were made partly in sterilised, partly in unsterilised water. Of those here to be considered, 12 were made in 1-litre flasks in Position A, and 2 were made in 11-litre bell-jars in Position B. Peptone was used in proportions varying from ·001% to ·0001%, usually in the former percentage, the Bacteria growth being induced by it in some cases once only, in others as many as six times in the same experiment.

The period occupied by Infusoria in clearing the water varied somewhat in the different experiments, apparently also in proportion to the strength of the peptone. Not always exactly observed, the period ranged in 15 exact records, from 3 to 8 days, the average being 6 days, from the time when the peptone was added, the Bacteria usually assuming a very strong growth within 24 hours later.

In some experiments in which this cycle of events was repeated a few times, a point was reached when the culture became "sick" and stagnant, the Bacteria growth being feeble, and the Infusoria falling off.

But in most cases the same process was repeated as far as the experiments were carried.

In experiments with sterilised water, the Infusorian mostly employed for inoculation was of the form which was referred to *Strombidium*, including probably two, if not three, distinct species. This Ciliate, though often lost sight of and superseded by smaller forms, was retained in some experiments for a long period. In one case it continued fairly numerous as late as the 67th day, after having cleared the water of four successive cultures of Bacteria which were grown on peptone introduced on the 1st, 13th, 39th, and 49th days, severally.

Following the destruction of a strong Bacteria culture by Infusoria, there arises commonly, if not invariably, a more or less heavy deposit of flocculent white patches in the water. The nature of this deposit, possibly the excretory product of the Infusoria, was not ascertained. In one experiment which had been five times impregnated with peptone within a period of 29 days, a sixth impregnation of the water decanted off to a clean flask on the 34th day did not produce any distinct Bacteria growth, or any recurrence of the Infusoria, the water remaining sickly in appearance. But a similar addition of peptone to the original flask with its deposit, which had been refilled with clean sterilised "outside" water, produced a strong Bacteria growth, the Infusoria continuing fairly numerous for some 3 weeks later. In the former case conditions had apparently arisen in the water, such as to resist further Bacteria growth, the Infusoria being consequently deprived of their food-supply.

These observations, though passing beyond the range of the subject of this paper, seem to deserve notice, as emphasizing the intimate relationship existing between Infusoria and Bacteria in the sea, and the destructive action of the former on the latter in experiments. This bactericidal action may be peculiar to certain species, or again may not in these be an essential feature of their natural existence : *Euplotes*, for example, which is rapidly destructive of Bacteria, and will apparently thrive on them alone indefinitely, was at first found to be feeding largely on the spores of *Chlorodendron*. One point seems certain, that in so far as such Infusoria may occur in experiments, their presence is not in itself to be regarded as nocuous, but rather, on the contrary, as an indication of the presence of unhealthy conditions which they are directly engaged in counteracting.

As regards the influence of these common forms of Bacteria on the experiments with the zooplankton, specimens of Calanoida and other species, more especially small or young forms, were kept alive on several occasions in the presence of these cultures for a considerable period, in one case through 4 successive growths of Bacteria, extending over some 6 weeks, the maximum life recorded—strangely, in this last-mentioned experiment—being 48 days. Some notes concerning a few of these experiments are appended :—

1-litre Flasks.

(No. 141.) In sterilised "outside" water, impregnated once with peptone, on the 1st day, and cleared of Bacteria on the 9th day by *Euplotes*.

Of about 6 Calanoids which were introduced on the 13th day, 3 (*Acartia*) were alive and active 34 days later. The maximum life period was not recorded.

(No. 140.) In sterilised "outside" water, similarly impregnated once with peptone, and cleared of Bacteria on the 8th day by a mixed culture of Infusoria.

Of about 12 Calanoids introduced on the 14th day, about 6 were alive after 7 days, 2 after 10 days, 1 after 20 days. The last was not alive on the 31st day.

(No. 122.) In unsterilised "outside" water, impregnated twice with peptone, on the 1st and 21st days, and cleared by contained Infusoria on the 5th and sometime prior to the 30th day, respectively.

Of the Calanoids contained in the water at the outset, 2 or 3 adult *Temora* were alive on the 30th day, and 1 on the 33rd day.

The water was aerated for a time on the 21st and 23rd days.

(No. 121.) In unsterilised "outside" water, impregnated four times with peptone, on the 1st, 28th, 33rd, and 38th days, severally, and cleared by contained Infusoria about 5 days later in each case.

Of several small forms in the contained zooplankton, 1 *Balanus* nauplius was recorded alive as late as the 21st day ; a few Calanoids were alive on the 28th day ; and 2 Calanoids were alive on the 48th day. The water was decanted off into a clean flask on the 8th day.

11-litre Bell-jars.

(No. 145.) In unsterilised "outside" water, impregnated with peptone on the 1st day only, and cleared by the contained Infusoria on the 7th day.

20 or 30 small Calanoids were alive on the 10th day, about 4 on the 29th day. None were observed on the 42nd day.

(No. 144.) In unsterilised "outside" water, impregnated with peptone on the 1st day, and again in smaller quantities on 5 days successively, from the 8th to the 12th day.

5 small Calanoids were observed alive on the 42nd day.

In both of these last-mentioned experiments the water became extremely foul on the 3rd day especially. In the second it was siphoned off and back into the bell-jar on that day, for aeration. In the first, it was not disturbed.

In these extreme cases, in which the Bacteria were grown, sometimes repeatedly, in enormous numbers, the specimens were directly exposed to the chemical changes produced in the water, apart from the intervals when it was cleared, for about 4 or 5 days or longer as often as the Bacteria growth was renewed. In No. 121, for example, at least 2 Calanoids survived, after nearly 7 weeks, an aggregate period of intense Bacteria growth amounting to about 16 days. And in most cases the water was not aerated or disturbed. From those results and from others obtained in similar experiments, it seems evident that the influence of common Bacteria of this character, occurring in comparatively small numbers in the ordinary experiments, must be so slight as to be almost negligible ; while the occurrence of Infusoria in the water can only be regarded as counteractive to them, and probably as beneficial in the presence of any unhealthy conditions that arise.

In all of these experiments no food was given other than was already present in those in which the water was unsterilised. Apparently the specimens were feeding on the Infusoria, and judging from the appearance of the excreta this seemed to be the case.

So far as they have been observed, the Bacteria which can be of serious harm to Copepoda in such experiments seem to be of infrequent occurrence in the water employed. Two forms only have been definitely recorded, to both of which allusion has already been made : the one forming irregular white slimy strands through the water (p. 566) ; the other giving a carmine-coloured tinge to objects attacked or invested (p. 565). Each of these has been twice observed, and both have proved in each case quickly fatal to all specimens that were contained in the infected vessel, though an endeavour to cultivate the second form has twice failed.

Twin Gastrulæ and Bipinnariæ of *Luidia sarsi*, Düben, and Koren.

By

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With Figures Pls. I–III (Figs. 1–21).

Early in June of this year (1914) I received from the Plymouth Marine Laboratory through the kindness of Dr. E. J. Allen, F.R.S., several Thermos flasks containing quantities of a culture of *Luidia* in the early blastula stage. This culture was made for me by Mr. James Gray, King's College, Cambridge, to whom, and to Dr. Allen, I desire herewith to express my indebtedness. The larvæ were little the worse of the journey to Glasgow, but it seemed to me that they showed even greater irregularities of form than might have been expected from Mortensen's (13) description of blastula formation in our species. However, in the end, abundance of perfectly typical young bipinnariæ* were secured from the contents of the various flasks. The abnormal larvæ became gradually fewer through death, and those which survived could be isolated without much trouble, since they exhibited less capacity for keeping near the surface of the water than their healthier brethren. A great many of the early malformations were of the nature of double or twin formation, and it soon became evident that the teratological type in question, namely, double monstrosity, was about to receive a more varied expression, and to attain a more advanced stage in development, than it had ever before been my good fortune to find in any starfish culture.

In the accompanying illustrations two series of abnormal larvæ are figured, one at the gastrula stage (Figs. 1–11), and the other at that of the early bipinnaria (13–21). As a description is appended to each figure, only questions of general interest need be dealt with here.

Classification. In the systematic teratology of vertebrates, Double

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* Two points in normal development may be noted here. (1) There does not appear to be an auricularia stage in the formation of the bipinnaria, the preoral and postoral bands being separated from one another antero-dorsally by a distinct interval at the time when they are first recognisably differentiated in this field (see 7, p. 232). Indeed, the relatively great width of the interval in question would by itself enable us to distinguish the larva of *Luidia* from those of *Asterias rubens*, *A. glacialis*, and *Porania pulvillus* during the first fortnight of bipinnarial life. (2) The small structure arising posteriorly from endoderm and interpreted by me as a rudimentary posterior enterocoelic growth in *Asterias rubens*, *A. glacialis*, and *Porania pulvillus* does not appear to be formed in *Luidia* (see 7, p. 233).

Monstrosities are conveniently divided up into Anadidymi, Katadidymi, Anakatadidymi, Mesodidymi (5 ; 14 ; 6, p. 3). To these a small group falls to be added containing the few recorded examples of simple longitudinal or parallel union (6, pp. 4, 29), which I venture to suggest may suitably be termed Paradidymi. The Anadidymi are, of course, forms with the anterior end more or less double, and the posterior end single ; in the Katadidymi these conditions are reversed. The Anakatadidymi show anterior and posterior doubling, but are single in their middle regions, while the converse relations are characteristic of the Mesodidymi. In the Paradidymi doubling occurs in an equal or sub-equal degree throughout the whole of the longitudinal axis of the twins.

In fishes and other vertebrates, the notochord, the vertebral column, the central nervous system and the alimentary canal, serve as our principal guides in judging to which group a particular double monster should be assigned. In double bipinnariæ, on the other hand, we have to depend entirely on the alimentary canal, inasmuch as the only other easily recognisable longitudinal structure, namely, the posterior ciliated band, owing to its superficial position, in most cases shows a greatly lessened amount of doubling through the working of "regulation" processes. Nevertheless, if the alimentary canal be taken as a guide, it is remarkable how readily the various types of duplex bipinnariæ fall into the same kinds of groups as double-monster fishes. Thus Figs. 13 and 14 illustrate longitudinal or parallel union and are therefore Paradidymi ; Figs. 16 and 17 belong to the Anadidymi ; Figs. 18 and 19 to the Katadidymi ; Fig. 20 is Anakatadidymous, and Fig. 21 Mesodidymous in type. Probably, further search among the abnormal bipinnariæ would have revealed a still fuller and more representative series. There remains to make mention of Fig. 15, which illustrates what may be called tangential union, and would no doubt have included the bipinnaria from the larva shown in Fig. 7 had survival been allowed. The twin embryonic axes, as represented here by the alimentary canals, are independent of, and widely divergent from, one another, but there is superficial union of the lateral or frontal body-walls. Among monster fishes we have no exact counterpart of this type, since, owing to the manner in which the twin embryonic axes develop, practically the only alternative to axial union is an Anakatadidymus effected through the intermediary of the yolk-sac. However, in the amniotic vertebrates, and particularly in the mammals, numerous instances occur in which, without axial union being present, the twin organisms are united to one another by paraxial or superficial structures.

The twin bipinnariæ of *Luidia* are not directly comparable with the double Echinus-rudiments noted by Metschnikoff (11) and described in detail by MacBride (10), since the latter appear late in development, and their formation is a consequence of the abnormal persistence and differentiation of one particular organ, viz. a right hydrocoele. The same thing is true of the changes characteristic of double hydrocoele in the developing *Asterias* larva (7, p. 275). As regards structure, suggestive analogies can be drawn between our bipinnariæ and the abnormal medusæ described by Allmann (1) and Browne (2). In normal embryology perhaps the most interesting parallel is to be found in the development of the Annelid *Lumbricus trapezoides* Dugès, in which a double gastrula, giving rise to two complete earthworms, is produced by fission of the segmenting cell-mass (9). The converse process, namely, *fusion* of two ova, has been shown to be possible before (16 *Ascaris*) and after (16 *Ascaris*, 3 *Sphærechinus*) fertilisation, and also during the blastula stage (12 *Sphærechinus*). In general, such fusion tends to produce double monstrosities resembling our bipinnariæ, but sometimes a perfectly single organism of larger than normal size is the result (16 ; 3).

Causation. E. Haeckel (8, 1869) discovered that the segmented egg of a Siphonophore (*Crystallodes*), if artificially divided, could give rise to several partial embryos, and E. B. Wilson (15, 1893) found that during the early stages of segmentation in *Amphioxus* each of the component cells, if separated from the rest, could develop into a perfect gastrula, while imperfectly double gastrulæ occurred abundantly in cultures which had been subjected to shaking during the two-celled stage. A series of such gastrulæ is shown in 15, Pl. XXXIV, Figs. 66–73, while in Pl. XXXVII, some of the partially double stages which led up to them (four-celled, eight-celled, blastulæ) are also illustrated. As is well known, similar or allied phenomena have been demonstrated to occur in the development of many other ova, and there is now an extensive body of literature dealing with experiments on the subject. Without going into details for other groups, we may note that the ova of Asteroids were early found to react to experiment in much the same way as those of *Amphioxus*, and, what is more remarkable, it was ascertained by Driesch (3) that as late as the blastula stage either half of a developing ovum (*Asterias glacialis*, *Astropecten*) bisected transversely or longitudinally could give rise to a bipinnaria. Thus in Asteroids it appears that single cells in the earliest stages or cell masses at a later stage can, if isolated, produce whole larvæ. On the other hand, if the cells or cell masses in question are incompletely separated from one another, partial doubling or twin formation may result.

Usually in starfish ova, doubling of this kind is associated with disturbances so profound that differentiation ceases in the gastrula stage. In my own experience great numbers of partially double blastulæ have appeared in different cultures of *Asterias rubens*, *A. glacialis*, and *Porania pulvillus*, but none of these was observed to reach even the early bipinnarial stages, and so far as I know such stages have not been figured or described. Possibly the ova of *Luidia* possess unusually great potentialities of duplex development, but we may, perhaps, conjecture that the long-continued shaking which the cultures would suffer during their journey (the Thermos flasks were left only three-quarters full for reasons connected with aeration) effected a physiological separation of masses of cells during the formation of the blastula, and at the same time diminished their vitality less than do the more abrupt experimental methods commonly employed in laboratory work.

Mode of Formation. Among Fishes the first noticeable feature in the genesis of double monstrosities is that two centres of gastrulation arise on the margin of the blastoderm. Next, the resulting embryonic axes are either brought together so as to unite posteriorly, producing the anadidymous type, or else remaining separate they give rise to anakatadidymous union of the embryos by means of the yolk-sac. The katadidymous condition is extremely rare, and, indeed, probably never occurs in perfect form. In the birds and mammals the larger proportion of double monsters arises in connection with two centres of embryo formation, but Katadidymus is not uncommon, being caused in most cases by fission of the posterior end of a developing embryonic axis. In fishes, birds, and mammals, since growth of the axis takes place almost entirely from before backwards, true anterior fission either does not occur or is extremely limited in extent. On the whole, we see that throughout the vertebrates the important feature in the production of double monstrosities is the presence of two foci of embryo formation, and that in the simplest group, the fishes, these foci are, to begin with, centres of gastrulation. As regards the Asteroids, a glance at the series of illustrations to this paper will show that here also the formation of two centres of gastrulation precedes bipinnarial twinning. Two more or less separate archentera are produced, and various other structures are partially or completely doubled. In the end the two archentera may remain separate from one another (Figs. 1–4, gastrulæ ; Figs. 13–15, bipinnariæ), but if the foci of gastrulation are very close together, the infolding process may amalgamate them, giving rise to an archenteron bifid in front and single behind (Fig. 5, gastrula; Fig. 16, bipinnaria). Again, in the case of a markedly bi-lobed blastula an originally single invagination may, during inward growth, divide into two branches (Fig. 6, gastrula; Fig. 17, bipinnaria), but we must often leave the question open whether there has been anterior fission or posterior fusion of archentera (Figs. 7, 8, gastrulæ). It is evident, further, that anterior fusion of the archentera can take place (Figs 9–11, gastrulæ; Fig. 19, bipinnaria). In Fig. 20 fusion of the expanded stomachal regions of the archentera is exhibited by a specimen with "back-to-back" union. Fig. 18, on the other hand, illustrates a case of "face-to-face" union in which the derivatives of two entirely separate archentera share a common buccal cavity. In Fig. 21 (Mesodidymus) the buccal cavity and rectum are single, while the œsophagus and stomach are doubled and there is a composite enterocoelic cavity between them. Fig. 7 shows triplicity in a modified form—the only instance of triplicity observed.

An examination of the various abnormal bipinnariæ figured will show that each archenteron tends to produce a pair of enterocoeles. In most cases all four persist (Figs. 13–15, 17, 18, 20). Sometimes two from different pairs (right of left pair and left of right pair) are united together (Figs. 19, 21). More rarely these two have either never been formed or have disappeared at a very early stage (Fig. 16).

As regards the ciliated bands we note that their preoral and postoral portions never become mixed—that is to say, the preoral portion of one "twin" always unites with the preoral of the other, and the postoral with the postoral. The general arrangement of these bands, and of the larval fields they enclose, makes it patent that quite remarkable powers of developmental "regulation" or "making the best of things" must in many cases have been at work.

SUMMARY.

The various types of twin *Luidia* larvæ may be classified according to the same system as Double Monstrosities among vertebrates, the alimentary canal of the larvæ being taken as their representative axial structure.

The causation depends on early partial separation of cells or of cell masses, accompanied by a minimal interference with the vitality of the whole.

Doubling (partial or complete) of the gastrula invagination is the great step on which the differentiation of twin bipinnariæ depends.

This differentiation shows very markedly the working of "regulation" processes in the course of which, when union of structures occurs, the union is always between structures of homologous origin. Thus preoral and postoral bands, enterocoeles, and particular regions of the alimentary canal, unite each with its own counterpart.

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DESCRIPTION OF FIGURES.

LETTERING EMPLOYED.

b.cav.	Buccal cavity.
bl.	Blastopore (anus of larva).
entc.	Enterocoele.
entc'.	Region of archenteron which produces the enterocoele.
entc.l.	Left enterocoele.
entc.r.	Right enterocoele.
m.o.	Mouth opening.
oes.	Œsophagus.
oes'.	Region of archenteron which produces the œsophagus.
po.cil.bd.	Postoral ciliated band.
pr.cil.bd.	Preoral ciliated band.
rect.	Rectum.
stom.	Stomach.
stom'.	Region of archenteron which gives rise to the stomach.

PLATE I.

Figs. 1–4.—Examples in which the archentera from two foci of gastrulation have remained separate. In Fig. 1 the blastopores are near one another and the archentera are parallel and equally developed. Compare the bipinnarial stage shown in Fig. 13. In Fig. 2 the blastopores are again near one another, the archentera being unequal; compare the bipinnarial stage shown in Fig. 14, though in the latter the inequality has manifested itself later and been less pronounced. In Fig. 3 the blastopores are a considerable distance away from one another and the archentera are markedly unequal; compare also Fig. 7. In Fig. 4 the foci of gastrulation have appeared on opposite sides of the larva.

Figs. 5–8.—Examples in which the blastopore being single, the archentera are bifid anteriorly. In Fig. 5 the doubling only affects the anterior or enterocoelic-œsophageal part of the archenteron; cf. the bipinnariæ shown in Figs. 16 and 17. In Fig. 6 the doubling reaches as far back as the commencement of the stomach; cf. anterior portion of the bipinnaria shown in Fig. 20. In Fig. 7 there is doubling to a like degree and in addition there is a small, entirely independent archenteron with its own blastoporic opening on one side; the larva thus exhibits a modified form of triplicity and is the only triple monster obtained. For parallel instances in Fishes see 6, pp. 33, 35. In Fig. 8 the doubling extends as far back as the stomachal region; cf. posterior half of the bipinnaria shown in Fig. 20.

Figs. 9–11.—Examples in which there are two separate blastopores, but the archentera are united in front to a greater or less degree. In Fig. 9 the archentera are equal and fused only at their extreme anterior ends; cf. the bipinnaria shown in Fig. 19. In Fig. 10 there is the same condition, but the archentera are unequal. In Fig. 11 the union reaches back to the stomachal region.

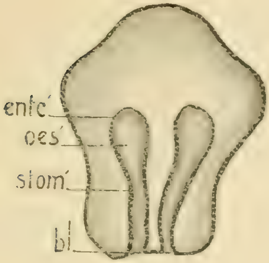


FIG. 1.

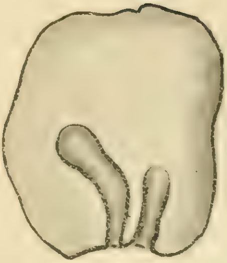


FIG. 2.

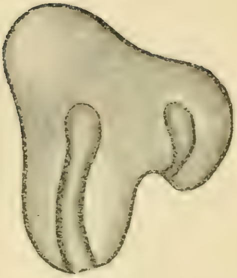


FIG. 3.

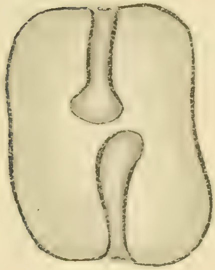


FIG. 4.

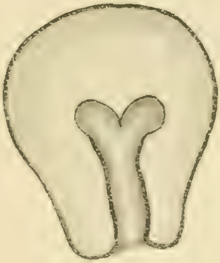


FIG. 5.

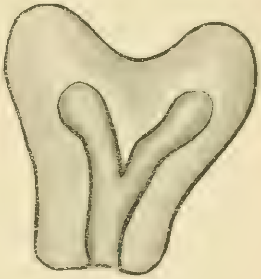


FIG. 6.

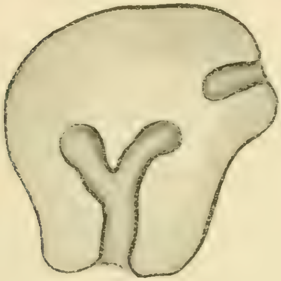


FIG. 7.

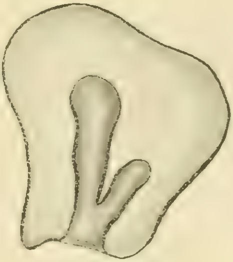


FIG. 8.

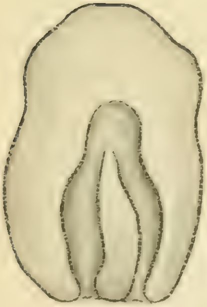


FIG. 9.

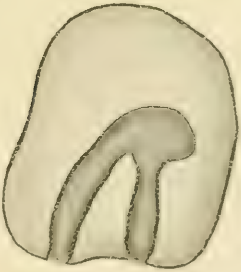


FIG. 10.

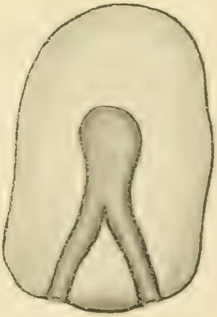


FIG. 11.

PLATE II.

(*For lettering see p.* 584.)

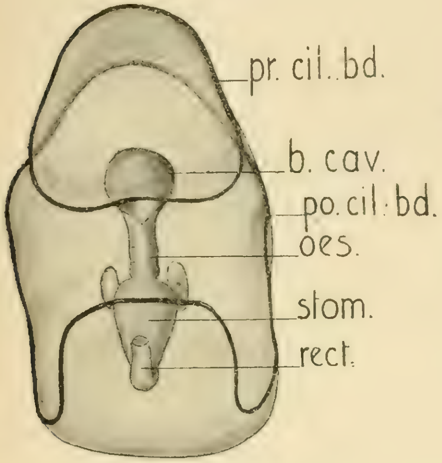
Fig. 12.—Normal bipinnaria of Luidia of same age as the twin bipinnariæ described. It will be noted that the preoral and postoral ciliated bands are completely developed and that in the alimentary canal, buccal cavity, œsophagus, stomach, and rectum can all be made out. There is a pair of enterocoeles, the left one being provided with a hydropore.

Figs. 13–21.—A series of double monster bipinnariæ about six days old, showing different kinds and degrees of duplicity. Here we must pay attention to a number of details, e.g. the preoral and postoral bands and the surface areas which they mark out, also the mouth and buccal cavity, the œsophagus, stomach, and rectum, the right and left enterocoelic cavities and the hydropore and hydroporic canal. In general the doubling is greater internally than externally, the enterocoeles and various parts of the food-canal being sometimes in two sets without a corresponding degree of division being exhibited on the surface of the body.

Fig. 13 is an example of parallel lateral union, as seen from the dorsal aspect. The whole of the food-canal is doubled, the mouth and anus in both cases looking in the same direction. Each food-canal has its own pair of enterocoeles, the left one in both instances developing a hydropore and hydroporic canal. The whole bipinnaria is broader than normal; there is a single preoral ciliated band enclosing the widened frontal field; the postoral ciliated band is also single, but shows a deep backwardly directed sinus on the ventral side marking off the twin anal fields from one another.

In Fig. 14 one set of structures is much better developed than its neighbour, the latter not showing mouth or anus, though provided with œsophagus, stomach, intestine, and a pair of enterocoeles. Only one of the preoral ciliated bands is properly differentiated, viz. that in connection with the frontal end of the better developed twin. The view is from the ventral aspect.

Fig. 15.—A double monster bipinnaria in which one of the twins is smaller than, and set at right angles to, the other. The smaller has no mouth and its frontal field is deficient in size. The postoral ciliated bands run into one another.


pr. cil. bd.
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po. cil. bd.
oes.
stom.
rect.

Fig. 12.

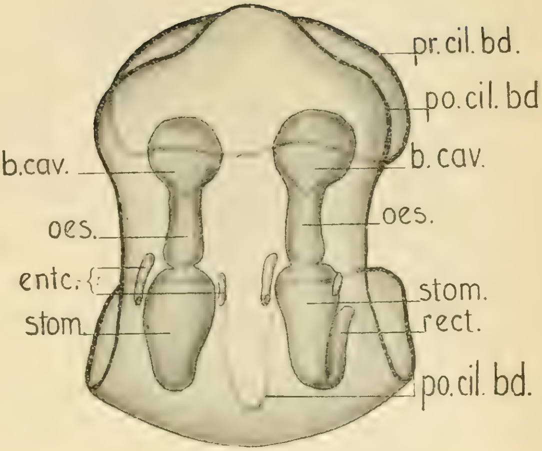
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Fig. 13.

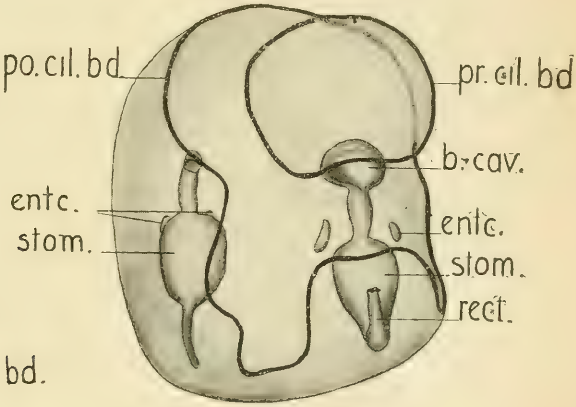
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Fig. 14.

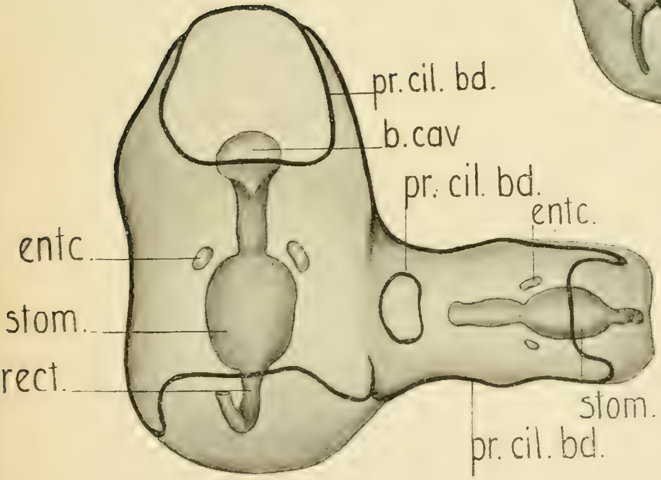
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Fig. 15.

PLATE III.

(*For lettering see p.* 584.)

Fig. 16.—A bipinnaria in which there is doubling of the mouth, buccal cavity, and first portion of œsophagus. The anterior end of the archenteron at the end of gastrulation must have exhibited a very slight degree of doubling. The frontal extremity of the larva is broadened, but in other respects the bipinnaria looks normal; cf. Fig. 5.

Fig. 17.—A bipinnaria with anterior doubling and posterior union. The two frontal fields and buccal cavities face one another and lead into a single œsophagus which is continued backwards into a single stomach, intestine, and rectum, the anus being in the middle of the posterior surface. There are two pairs of enterocoeles, the left enterocoele of the right twin and the right enterocoele of the left twin being shown in the drawing, and the first-named has a hydroporic opening. The two preoral ciliated bands are distinct from one another, but the postoral bands are continuous on opposite sides. The circumoral food-collecting areas are also united.

Fig. 18.—A double monster bipinnaria showing symmetrical ventral union of the twin components, the fusion being somewhat greater at the anterior than at the posterior end of the composite larva. There are two frontal areas bounded by preoral ciliated bands on opposite sides of the bipinnaria, but each frontal area and ciliated band is to be looked upon as composite, that is, derived in part from one and in part from the other of the twin components. The buccal cavity is single, but also composite, and it communicates with the surface by two mouth openings on opposite sides of the larva. The two postoral ciliated bands are ununited though they approach one another posteriorly. Œsophagus, stomach, etc. are separate and there are two pairs of enterocoelic pouches. The circumoral food-collecting areas merge into one another.

Fig. 19.—A bipinnaria showing posterior doubling of the principal internal structures. The view is from the dorsal aspect. The preoral ciliated band, the buccal cavity, and the first part of the œsophagus are single, while the rest of the œsophagus, the stomach, and the rectum are doubled. Note as regards the enterocoeles that the left one of the right twin and the right one of the left twin have fused together to form a single composite sac provided with a hydropore. The circumoral fields run freely into one another on the ventral aspect of the larva.

Fig. 20.—A double monster bipinnaria with the components united back-to-back by their dorsal body-walls. Internally there is a composite stomach, but otherwise the food-canals are separate. The rectum and anus of the twin to the left of the drawing were lost. The two preoral and postoral bands and the two circumoral areas have remained separate on either side, and there are two pairs of enterocoelic pouches. As regards internal structure we may describe this specimen as anakatadidymous, that is, showing duplicity both anteriorly and posteriorly.

Fig. 21.—A double monster bipinnaria in which although the buccal cavity and the rectum are single, there is doubling of the intervening regions, namely, the œsophagus and stomach. The view is from the dorsal aspect, and the duplex structures lie side by side, and look in the same direction. Three enterocoelic sacs are present. The middle one possesses a hydropore and has evidently arisen by the fusion of a right sac belonging to a left twin with a left sac belonging to the right twin. Compare with Fig. 19. In other respects the bipinnaria, though slightly broader than usual in its middle region, is superficially almost normal. As far as internal structure is concerned we may describe this bipinnaria as exhibiting the mesodidymous condition.

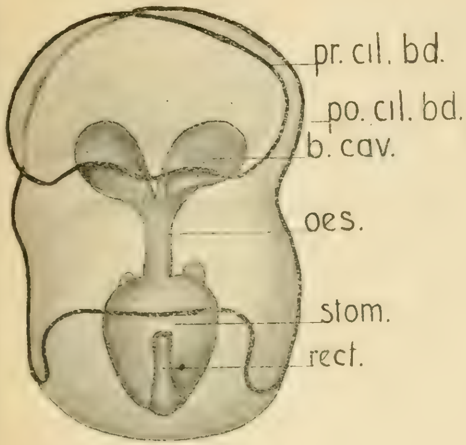
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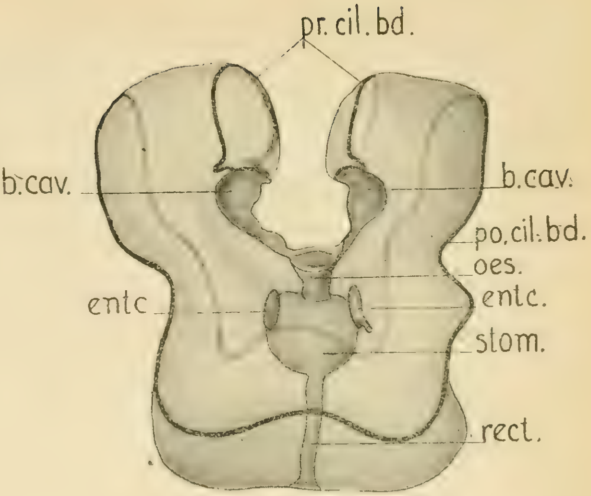
Fig. 16.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rect.

Fig. 17.

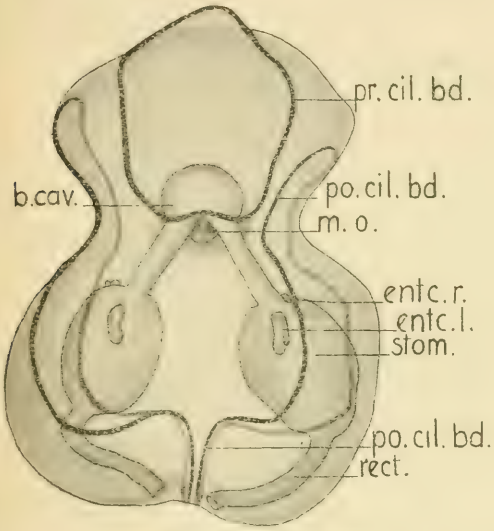
pr. cil. bd.
b.cav.
po. cil. bd.
m. o.
entc. r.
entc. l.
stom.
po. cil. bd.
rect.

Fig. 18.

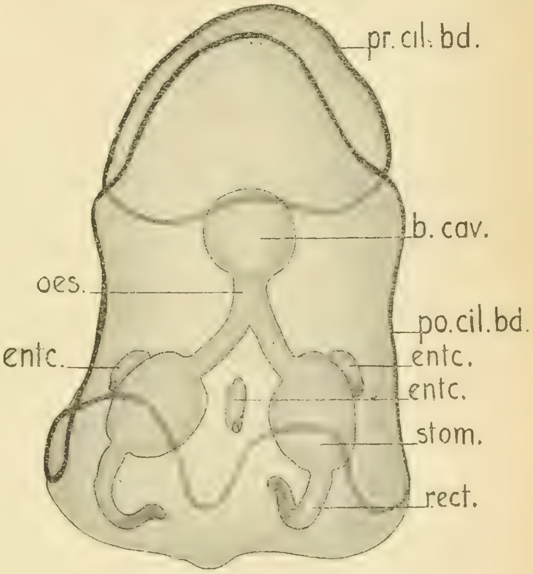
pr. cil. bd.
b. cav.
oes.
po. cil. bd.
entc.
entc.
entc.
stom.
rect.

Fig. 19.

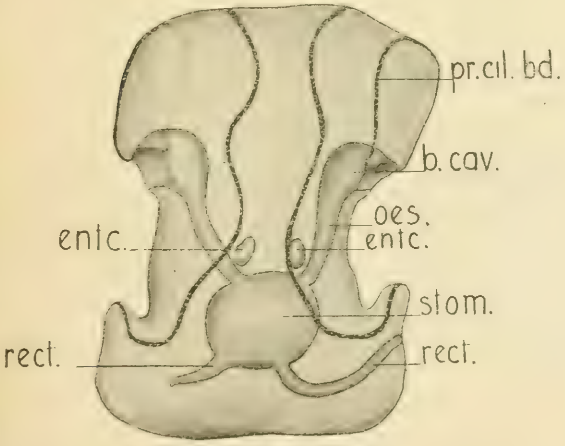
pr. cil. bd.
b. cav.
oes.
entc.
entc.
stom.
rect.
rect.

Fig. 20.

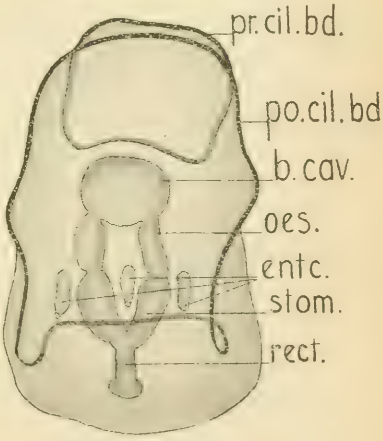
pr. cil. bd.
po. cil. bd
b. cav.
oes.
entc.
stom.
rect.

Fig. 21.

A Method of Separating Sponge Spicules by Filtration.

By

L. R. Crawshay, M.A.

The separation of sponge spicules by the method here described has been employed by me from time to time, for some years past, with such satisfactory results that it may be recommended with confidence as a useful and time-saving method of preparing these or other minute hard structures for microscopic examination.

For the suggestion of gun cotton as a filtering medium I am indebted to Mr. D. J. Matthews, the simple apparatus adopted for its use being as follows :—

A piece of glass tubing, about half an inch in inside diameter and eight inches in length, is drawn out at one end rather abruptly to an opening of about one-eighth of an inch or less, and this tube is passed through a cork which serves to support it while resting loosely in the neck of a flask or other waste receptacle. A very small piece of gun cotton, first teased out evenly, is then pressed lightly with a glass rod into the lower drawn-out end of the tube. This plug should be of the smallest possible bulk sufficient to ensure easy filtration, and need not be more than about one-eighth of an inch in depth.

The spicules having first been cleaned in a test tube by boiling in nitric acid or Eau de Javelle, and the test tube having been filled up with distilled water in the ordinary manner, the contents are poured into the tube and, the liquid passing through the filter, the tube is refilled with distilled water and afterwards twice with 90 % alcohol. The filter carrying the spicules is then pressed backwards into the tube and shaken out through the broad end into a small test tube in which the filter is thoroughly dissolved by shaking it up in equal parts of pure ether and absolute alcohol, the tube being fitted with a cork to prevent evaporation of the ether. When the spicules have settled the liquid is pipetted off and the test tube is refilled with ether and alcohol and shaken up as before. After pipetting off for the second time the tube is then filled with 90 % alcohol, from which after being allowed to settle again, the spicules may be removed for mounting on the slide. In this way the gun cotton is removed in solution. If it is not, a deposit will be left on the slide when the liquid is burnt off which will more often spoil the preparation, and there is a danger too of the spicules being partly fused by the high burning temperature of the gun cotton.

The method has the advantage of much saving of time over that of allowing the spicules to settle naturally in a test tube through the process of cleaning and dehydration, and ensures a degree of completeness which is greater perhaps than either this or the centrifuge method. When a very small fragment only of a sponge is available, or where spicules are of very small size or scarce in the specimen, it is especially serviceable as retaining the whole of the spicules within a narrow compass, thus obviating loss of material. Filtration may be accelerated by means of a pressure pump if necessary, though it is better as far as possible to avoid this owing to any additional pressure tending to pack the spicules too closely on the filter or to break them. If through the filter being too lightly adjusted too rapid filtration should occur, any spicules that may have passed through can of course be recovered by refiltering the waste liquid, and in view of this it is best to observe always the same precaution in regard to cleanness for the flask as for any tubes or pipettes that are used. Any of the latter that have been used in contact with the dissolved gun cotton should be washed in the first instance in ether and alcohol to ensure thorough cleaning and the removal of spicules clinging to traces of the residue.

Though the method has been employed almost solely for the separation of sponge spicules, there seems no reason why it should not be found of equal service in the treatment of Diatom tests, the shields of Coccolithophoridæ, or any other minute structures which are uninjured by ether or alcohol.

Polychæta of Plymouth and the South Devon Coast, including a list of the Archiannelida.

By

E. J. Allen, D.Sc., F.R.S.,

Director of the Plymouth Laboratory.

INTRODUCTION.

THE present list of Polychætes is a revision of the list published in 1904, as part of the general list of the Plymouth Marine Invertebrate Fauna (*Journ. Mar. Biol. Assoc.*, vol. vii., 1904, p. 219). It is the result of work carried on in the intervals of other researches, as opportunity offered, and there are in all probability a good many gaps still to be filled.

To the Plymouth records I have added those obtained at Salcombe (*Journ. Mar. Biol. Assoc.*, vol. vi., 1900, p. 151) and at Exmouth (ditto, vol. vi., 1902, p. 295), a few records from the Teignmouth estuary, and Major Elwes' records from Torquay (*Journ. Mar. Biol. Assoc.*, vol. viii., 1908, p. 197, and 1909, p. 347 ; vol. ix., 1910, p. 59), the latter dealing only with Polychætes found on the shore. Mr. Crawshay's records, from the valuable series of dredgings S.S.W. of the Eddystone to fifty fathoms, have also been included (*Journ. Mar. Biol. Assoc.*, vol. ix., 1912, p. 339).

Apart from the Archiannelids there are comparatively few species in the list which I have not been able to examine myself. In all cases where no initials appear at the end of a paragraph the responsibility for the record is my own.

My thanks are due to Major Elwes for a number of mounted specimens of the Torquay species, which have been of great help, especially with the Syllidæ.

As regards nomenclature, after the name of each species, one or more references have been given to papers where a detailed description of the species intended is given. Whilst endeavouring as far as possible to make use of that name which will probably stand, elaborate discussions of nomenclature and synonymy have been in general avoided. The main object has been to make quite clear which form is intended. Considerable changes in the names used in the former list have been necessary, since our knowledge of the British Polychæte fauna has been greatly extended by the publication of several parts of Prof. McIntosh's

Monograph, and of important papers on Irish Polychætes by Mr. R. Southern. The character of the various dredging and trawling grounds in the Plymouth neighbourhood is fully described in the general account of the Plymouth Fauna (*Journ. Mar. Biol. Assoc.*, vol. vii., 1904, p. 159), where a chart of the area will also be found. Similar accounts of the Salcombe and Exmouth areas will be found in the respective reports.

The following list of the Plymouth grounds, with depth and general nature of the bottom, etc., may be useful for reference.

LIST OF PLYMOUTH COLLECTING GROUNDS.

Shore.

Rum Bay. This term is used to include the shore from Batten Breakwater to Jennycliff Bay. Shale rocks, with patches of gravel and sand. Some stony ground.

Drake's Island. Stony and rocky shore. Some patches of sand and a *zostera*-bed.

Mount Edgcumbe. At the mouth of the Hamoaze. Very similar to the rocky and stony ground on Drake's Island.

Rocks below Laboratory. Rocks of hard Plymouth limestone, with good rock-pools.

Dredging Grounds of Plymouth Sound.

Millbay Channel. 14–23 fms. Stones and mud. Free from growth of seaweeds.

Asia Shoal. 5–7 fms. Stony ground with some growth of red seaweeds.

Queen's Ground. 5–6 fms. The term is used to include the area from Queen's Ground Buoy to New Grounds Buoy and the ground around the latter, all situated at the western entrance to Plymouth Sound. The soil is shell gravel, with stones and shells. It is very free from mud and there is some growth of red seaweeds.

Duke Rock. 4–5 fms. Near the eastern entrance to Plymouth Sound. The bottom is rocky, with intervals of ground occupied by stones and shells.

The Cattewater. The inner Plymouth harbour, where the bottom is soft mud, which can be worked with a shrimp trawl. The trawlers often throw their refuse overboard here, and many of the outside species can survive for a time.

THE YEALM ESTUARY.

A sheltered estuary to the east of Plymouth, where a large body of pure sea-water extends for a considerable distance from the mouth, and the fauna is essentially marine.

OUTSIDE GROUNDS.

Shores.

Wembury Bay. A rocky shore, with intervals of sand. Some of the reefs give considerable shelter from the breakers, especially at the western side of the bay.

Reny Rocks. A reef of exposed, weed-covered rocks running from the Shagstone to the mainland.

Whitsand Bay. An exposed shore which consists chiefly of fine, shifting sand, with occasional rocky patches.

Dredging and Trawling Grounds.

Cawsand Bay. Depth 3–5 fms. An inshore, shallow, sheltered bay with a bottom of fine sand.

Whitsand Bay. Depth 4–8 fms. A shallow sandy bay, more exposed than Cawsand Bay.

Mewstone Ledge. Depth 10–15 fms. A ridge of soft red, conglomerate rock, free from growth of seaweed. The dredge breaks off portions of the rock.

Mewstone Shell Gravel and "Amphioxus" Ground. Depth 10–12 fms. Bottom of clean shell gravel.

Stoke Point Grounds. Depth 10–22 fms. Reefs of red conglomerate alternating with patches of gravel and sand.

Rame-Eddystone Grounds. Depth 25–30 fms. Trawling ground between Rame Head and the Eddystone. Bottom muddy gravel, with clean sand in places.

Looe-Eddystone Grounds. Depth 25–30 fms. An extension westwards towards Looe of the Rame-Eddystone Grounds. Bottom similar to that of the latter, but rougher.

Eddystone Grounds. Depth 28–35 fms. Bottom varied. They are fully described in this Journal, vol. v., p. 365.

EXPLANATION OF INITIALS.

The authorities for various records are indicated by their initials, a list of which is given below. Initials have reference only to the *paragraph* in which they stand. Where no initials are given at the end of any paragraph the records are by E. J. Allen :—

A.J.S.—A. J. Smith, Assistant at the Laboratory since 1895.
C.S.—Creswell Shearer.
E.J.A.—E. J. Allen.
E.J.B.—E. J. Bles.
F.W.G.—F. W. Gamble.
J.T.C.—J. T. Cunningham.
R.A.T.—R. A. Todd.
S.P.—S. Pace.
T.V.H.—T. V. Hodgson.
W.B.B.—W. B. Benham.
W.G.—Walter Garstang.

ARCHIANNELIDA.

Turbanella hyalina Max Schultze : Muller's Archiv., 1853, p. 241.

Plymouth. Found by Dr. C. Shearer on the glass of one of the Laboratory tanks, July 26th, 1909. Dr. Shearer states :—"This form is apparently most rare, having never been described since 1853. Apparently an Archiannelid with parapodia of a primitive kind. Usually placed in the Gastrotrichia."

Dinophilus tæniatus Harmer : Journ. Mar. Biol. Assoc. N.S. vol. 1, p. 119.

Plymouth. In rock-pools in the Sound far above low water, in March and April, not found in June (*Harmer, loc. cit.*). Found often in immense numbers in pools high up on the limestone rocks below the Laboratory and in front of West Hoe Terrace. Records of the occurrence of the species below the Laboratory were kept by Mr. A. J. Smith between 1906 and 1910. From these it appears that it was abundant from November to April, but absent or very scarce between May and October.

Dinophilus gyrociliatus Schmidt : *Shearer*, Quart. Journ. Micr. Sci. vol. 57, 1912, p. 337.

Plymouth. From sandy dredgings from Cawsand Bay. Can also be obtained in scrapings from the piles in Millbay Docks. Lived well in small aquaria and became established in the Laboratory tanks (Shearer, *loc. cit.*, p. 342).

Breeds all the year round in the Laboratory Tanks (C.S.).

Protodrilus flavocapitatus Uljanin : *Pierantoni*, Protodrilus. Fauna Flora Golf. Neapel. Mon. 31, 1908, p. 167.

Plymouth. The first record of Protodrilus at Plymouth is by

Bles (Jour. M.B.A., vol. 2, 1892, p. 343) who reared it from townettings taken in September. He considers the species to be *P. Leuckartii* Hatschek (Arbeit. Zool. Inst. Wien., vol. 3, 1880, p. 79).

Adults have since been found on the shore in numbers by Orton (Nature, vol. 91, 1913, pp. 85 and 348) at eleven different points between Salcombe and Looe, under stones and gravel near high-water mark, where small fresh-water streams join the sea. Orton records this species as *P. flavocapitatus* Uljanin.

CTENODRILUS PARDALIS Claparède : Beobactungen über Anat. u. Entw. wirbellos. Thiere a. d. K. von Normandie, 1863, p. 25.

PLYMOUTH. Found in the Laboratory tanks and also in pools at high-tide level below the Laboratory by Dr. C. Shearer. Some years it is very abundant in the tanks, in other years it is absent (C.S.).

NERILLA ANTENNATA Schmidt : *Goodrich*, Quart. Journ. Micr. Sci. vol. 57, 1912, p. 397.

PLYMOUTH. First recorded by Miss F. Buchanan (Rep. Brit. Assoc. 1892, p. 358). It has since been found to occur frequently in the Laboratory tanks, and also in scrapings from piles in the Cattewater.

Breeds from February to June in the Laboratory Tanks (C.S.).

SACCOCIRRUS SP. : *Goodrich*, Quart. Journ. Micr. Sci. vol. 44, 1901, p. 413 ; and *Pierantoni*, Ann. Mus. Zool. Napoli, vol. 2, no. 18, 1907.

PLYMOUTH. Found by Orton in Cawsand Bay together with Protodrilus, amongst stones and gravel just below high-water mark where a small fresh-water stream joins the sea. He thinks the species different from *S. papillocercus* Bobretzky (Nature, vol. 91, 1913, p. 348).

POLYGORDIUS LACTEUS Schneider : *Hempelman*, Zeitsch. wiss. Zool. vol. 84, 1906, p. 527.

PLYMOUTH. Dredged in clean shell gravel off the Mewstone and near the west end of the Breakwater. In clean shell gravel near the Eddystone and off Bolt Head.

HISTRIOBDELLA HOMARI van Beneden : *Foettinger*, Archiv. Biologie, V. 1884, p. 435. *Shearer*, Quart. Journ. Micr. Sci. vol. 55, 1910, p. 287.

PLYMOUTH. Usually found on the eggs of lobsters taken by fishermen, but normally an inhabitant of the branchial chamber (C.S.).

Breeding during the summer months.

Breeding in September (C.S.).

POLYCHÆTA.

SYLLIDÆ.

EXOGONE GEMMIFERA Pagenstecher: *McIntosh*, Mon. Brit. Ann. II. 1, 1908, p. 151.

PLYMOUTH. Common on the shore amongst the roots of Laminaria and other weeds, in the Sound and on the coast outside. Frequent in dredgings from the Sound. It also occurs in dredgings from deeper water, e.g. 2 miles off Yealm Point in 15 fms. and off the Eddystone in 30–35 fms.

Breeding: A number of specimens found amongst Ascidians from the piles in Millbay Dock in June carried eggs and embryos in different stages of development.

TORQUAY. Not uncommon amongst sea-weeds from half-tide mark downwards (*Elwes*, Journ. M.B.A., vol. 8, 1908, p. 197).

SPHÆROSYLLIS HYSTRIX Claparède: *McIntosh*, Mon. Brit. Ann. II. 1, 1908, p. 157.

PLYMOUTH. Frequent in dredgings from the Sound; occasional specimens amongst roots of weeds from the shore.

SPHÆROSYLLIS OVIGERA Langerhans: Wurmfauna v. Madeira, Zeitschr. Wiss. Zool. XXXII. 1879, p. 567.

PLYMOUTH. In the Sound near New Grounds Buoy. Several specimens have been taken.

The species seems to be quite distinct from *S. hystrix* as well as from *S. pirifera*, Claparède. The palps are very broad and the median tentacle is in a line with or more generally in front of the anterior eyes, as figured and described by Langerhans. The body is always coated thickly with sand and mud, which enables the specimens to be separated at once from the *S. hystrix* found in the same material. The body is covered with papillæ.

SPHÆROSYLLIS ERINACEUS Claparède, *var.*: *de St. Joseph*, Ann. Polych. Dinard; Ann. Sci. Nat. Zool. 1886, p. 207.

PLYMOUTH. Common amongst roots of Laminaria from Rum Bay.

The specimens differ from the descriptions and figures of Claparède and de St. Joseph in having the two anal cirri large and much swollen at the base.

Breeding: A specimen obtained in June had four large eggs on each segment from Segt. 9 backwards. The eggs were carried on the dorsal side of the segment. On the segments anterior to Segt. 9, four round tubercles were present on each, in positions corresponding to those occupied by the eggs.

GRUBEA CLAVATA, Claparède: Beobactungen, p. 41. Pl. XIII. Figs. 28–29. *de St. Joseph*, Ann. Sci. Nat. Zool. I. 1886, p. 200.

PLYMOUTH. From Laminaria roots, Rum Bay shore.

TORQUAY. One example from Laminaria root, Oddicombe Beach (*Elwes*, Journ. M.B.A., vol. 8, 1908, p. 197).

GRUBEA LIMBATA Claparède: Ann. Chètop. Naples, p. 208. *Viguier:* Arch. Zool. Exp. II. 1884, p. 103.

PLYMOUTH. From Laminaria roots from the Breakwater and Reny Rocks. Dredged near the east end of the Breakwater in 4 to 5 fms.

Four specimens have been obtained altogether, one in June with long swimming bristles. The specimens agree in all respects with the descriptions of Claparède and Langerhans. The buccal segment is hidden by a raised collar similar to that seen in *Eusyllis*.

GRUBEA PUSILLA Dujardin: *Langerhans*, Zeitschr. Wiss. Zool. XXXII. 1879, p. 565. *de St. Joseph*, Ann. Sci. Nat. Zool. I. 1886, p. 203.

PLYMOUTH. Amongst the roots of Laminaria from Rum Bay.

Breeding: Two females with embryos on the parapodia were seen in March.

PIONOSYLLIS LAMELLIGERA de St. Joseph: Ann. Sci. Nat. Zool. I. 1886, p. 163.

PLYMOUTH. In dredgings from Duke Rock, New Grounds, between Knap and Panther Buoys, and Mewstone Ledge. Amongst Laminaria roots from Reny Rocks.

TORQUAY. Very common in Laminaria roots (*Elwes*, Journ. M.B.A., vol. 8, 1908, p. 198).

PIONOSYLLIS DIVARICATA Keferstein: *McIntosh*, Mon. Brit. Ann. II. 1, 1908, p. 164. *de St. Joseph*, Ann. Sci. Nat. Zool. I. 1886, p. 160 as *P. longocirrata*.

PLYMOUTH. One specimen from dredgings from New Grounds.

TORQUAY. Three or four specimens from Corbyn's Head (*Elwes*, Journ. M.B.A., vol. 8, 1908, p. 198).

EUSYLLIS TUBIFEX (Gosse): *McIntosh*, Mon. Brit. Ann. II. 1, 1908, p. 173. (Probably the same as *E. Blomstrandi*, Malmgren as described by *de St. Joseph*, Ann. Sci. Nat. Zool. I. 1886, p. 171. Cf. *Southern*, Clare Island Survey, Pt. 47, Proceed. Roy. Irish Acad. XXXI. 1914, p. 32.)

PLYMOUTH. Very common in the Sound from the shore and in dredgings. Often met with in dredgings from outside, e.g. Mewstone Ledge and Eddystone Grounds.

Breeding: Females with ova and swimming bristles recorded in February and March.

TORQUAY. Fairly common amongst weeds covered with Polyzoa and Sertularia (*Elwes*, Journ. M.B.A., vol. 8, 1908, p. 198).

Breeding: Females with ova, some with well developed swimming bristles, in April.

Eusyllis monilicornis Malmgren: *de St. Joseph*, Ann. Sci. Nat. Zool. I. 1886, p. 169 (cf. *Langerhans*, Wurmfauna von Madeira, Zeits. Wiss. Zool. XXXII. 1879, p. 551).

Plymouth. Single specimens have been taken on a number of occasions from dredgings in the Sound, at Duke Rock and Asia Shoal. One from Mewstone Ledge.

The species is clearly distinguished from *E. tubifex* (Gosse) by its more robust form, and by the character of the setæ, the end pieces of which are of two kinds in each typical foot, the one short and stout, the other long and slender. The hinder part of the head generally carries a conspicuous patch of dark brown or black pigment.

Eusyllis lamelligera Marion and Bobretzky: Annélides du Golfe de Marseille, Ann. Sci. Nat. 6^e sér. II. p. 33. Pl. III. Fig. 9. *de St. Joseph*, Ann. Sci. Nat. Zool. I. 1886, p. 169.

Plymouth. Two or three specimens have been obtained from dredgings from Mewstone Ledge and Eddystone Grounds.

Breeding: A female with nearly ripe eggs was taken in July.

A well defined species, which can easily be recognised by the enlarged leaf-like shape of the first pair of ventral cirri. It is well described by Marion and Bobretzky.

Odontosyllis ctenostoma Claparède: *McIntosh*, Mon. Brit. Ann. II. 1, 1908, p. 182.

Plymouth. Very abundant on the shores of the Sound and frequent in dredgings from the Sound.

Breeding: A specimen in the swimming stage, with long setæ, was recorded in May.

Torquay. The most abundant of all the species of Syllids (*Elwes*, Journ. M.B.A., vol. 8, 1908, p. 199).

Odontosyllis fulgurans Audouin and Edwards: *McIntosh*, Mon. Brit. Ann. II. 1, 1908, p. 179.

Plymouth. Dredged at Queen's Ground (New Grounds), Mewstone Ledge, off Stoke Point and on Rame Eddystone Grounds. Usually not more than one specimen on each occasion.

Odontosyllis gibba Claparède: *McIntosh*, Mon. Brit. Ann. II. 1, 1908, p. 183.

Plymouth. Common in dredgings from Asia Shoal, Duke Rock, Queen's Ground and Millbay Channel.

Torquay. Several examples were found at Corbyn's Head (*Elwes*, Journ. M.B.A., vol. 8, 1908, p. 199).

Trypanosyllis zebra (Grube): *McIntosh*, Mon. Brit. Ann. II. 1, 1908, p. 169.

PLYMOUTH. Frequent in dredgings from Millbay Channel and Asia Shoal. Occasionally from other parts of the Sound. Yealm dredging. On the shore at Wembury Bay in a mass of yellow sponge.

TORQUAY. Fairly numerous among Laminaria roots from the rocks between Babbacombe and Oddicombe beaches (*Elwes*, Journ. M.B.A., vol. 8, 1908, p. 200).

TRYPANOSYLLIS CAELIACA Claparède: *McIntosh*, Mon. Brit. Ann. II. 2, 1910, p. 240.

TORQUAY. Four or five specimens from Oddicombe Rocks (*Elwes*, Journ. M.B.A., vol. 8, 1908, p. 201).

EURYSYLLIS PARADOXA (Claparède): *McIntosh*, Mon. Brit. Ann. II. 2, 1910, p. 241.

PLYMOUTH. Occasional specimens from Asia Shoal dredgings and from dredgings on the rocky ground south of the Breakwater. One or two from Laminaria roots from the shore at Reny Rocks.

Breeding: A specimen with hinder segments swollen with genital products from Reny Rocks in July.

TORQUAY. From Oddicombe, Corbyn's Head and Livermead (*Elwes*, Journ. M.B.A., vol. 8, 1908, p. 201).

SYLLIS (TYPOSYLLIS) ARMILLARIS (Müller): *McIntosh*, Ann. Mag. Nat. Hist. Ser. 8. vol. xi, 1913, p. 83. *McIntosh*, Mon. Brit. Ann. II. 1, 1908, p. 188; ditto II. 2, 1910, p. 238.

PLYMOUTH. Eddystone Grounds (*Weldon*, Journ. M.B.A., vol. 5, 1899, p. 481). A number of specimens from 20 to 50 miles S.S.W. of Eddystone in 42–49 fms. (L.R.C.). Frequent on all dredging grounds in and around Plymouth Sound. Amongst Ascidians from Millbay Dock. Occasional specimens from the shore.

The species was included in former lists (Journ. M.B.A., vol. 7, 1904, p. 219) as *Typosyllis alternosetosa*, de St. Joseph.

TORQUAY. Fairly common. Recorded as *Typosyllis alternosetosa* (*Elwes*, Journ. M.B.A., vol. 8, 1908, p. 199).

SYLLIS (TYPOSYLLIS) PROLIFERA Krohn: *Langerhans*, Zeit. wiss. Zool. XXXII, 1879, p. 530. *Claparède*, Glanures Zoot. parmi les Annél. de Port-Vendres. 1864, p. 70 (530) as *Syllis Armandi*. *McIntosh*, Mon. Brit. Ann. II. 1, 1908, p. 167 as *Pionosyllis hyalina* Grube and possibly in part, p. 161 as *Pionosyllis prolifera* Krohn.

PLYMOUTH. Common everywhere amongst weeds, etc., on the shore, as well as in dredgings from shallow water especially in Plymouth Sound.

TORQUAY. One of the most numerous of the Torquay Syllids. A very variable species (*Elwes*, Journ. M.B.A., vol. 8, 1908, p. 199).

There is some difficulty in deciding the correct nomenclature and synonymy of the three forms of Syllis which have been described by different authors under the names, *Syllis prolifera* Krohn, *S. variegata* Grube and *S. hyalina* Grube. After examining a considerable number of living specimens my own view is that two distinct species have been referred to under these names, which would most conveniently and probably according to the law of priority most correctly bear the names *S. prolifera* Krohn and *S. variegata* Grube. The name *S. hyalina* Grube has I think most frequently been applied to examples of *S. prolifera* (and possibly other species) which were not yet fully grown.* In *S. prolifera* Krohn the pharynx is comparatively short and stout, the single dorsal tooth is large and is usually situated at the hinder end of the first third of the pharynx. There is a considerable distance between the point of the tooth and the anterior edge of the pharynx.

The proventriculus is comparatively short and stout, being about the same length as the pharynx.

The end pieces of the bristles have very boldly bifid tips, the bifid character becoming more and more marked in the posterior segments, where the end pieces also become much shorter.

In the last few parapodia there is in each a single straight simple bristle dorsally, the tip of which is often with some difficulty seen to be bifid, and ventrally a single curved simple bristle with a boldly bifid tip exactly resembling the tip of the compound bristles.

The anterior segments contain a quantity of brown pigment on the dorsal surface. This pigment is in many specimens distributed fairly uniformly over the surface, but more generally it tends to accumulate along the posterior border of the segment forming a transverse brown bar. In other specimens again in addition to this posterior bar there is an accumulation of the pigment in the centre of the dorsal surface of the segment, a brown patch above each of the dorsal cirri, and a bar along the anterior border of the segment. The pattern thus formed tends to resemble that of *S. variegata*, but this pattern is not often found in *S. prolifera*, in which the uniform distribution of pigment on the dorsal surface with a posterior brown bar is the more characteristic condition.

The dorsal cirri are moniliform. They are distinctly long, as compared for example with *S. armillaris* or *S. gracilis*, and in well-grown worms have from 25 to 30 or even 40 articulations. They differ in length, being alternately long and short throughout the greater part of the body.

The *Pionosyllis hyalina* Grube described by McIntosh (Mon. Brit. Ann. II. 1, 1908, p. 166) is almost certainly this form in an immature condition, with the cirri not yet fully grown and thus having fewer articulations.

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* It should be noted that the *S. hyalina* of Malaquin is the *S. alternosetosa* de St. Joseph, recorded in the present list as *S. armillaris* (Müller) (Rech. sur les Syllidiens, 1893, p. 96).

The corresponding characters of *S. variegata* are described below under that species.

SYLLIS (TYPOSYLLIS) VARIEGATA Grube: *Langerhans*, Zeit. wiss. Zool. XXXII, 1879, p. 532, *Marenzeller*, Sitzb. mathem.-naturw. Cl. LXIX. Bd. I. 1874, p. 441. *McIntosh*, Mon. Brit. Ann. II. 1, 1908, p. 161 as *Pionosyllis prolifera* (Krohn).

PLYMOUTH. Not uncommon in dredgings from Millbay Channel and Asia Shoal. Off Yealm Head. One large specimen from the shore at Wembury Bay amongst Laminaria roots.

South by west of Eddystone in 44–49 fms. (*Crawshay*, Journ. M.B.A., vol. 9, 1912, p. 340).

The distinction between *S. variegata* and *S. prolifera* will be seen on comparing the following characters. In *S. variegata* Grube the pharynx is long and slender, extending through as many as ten segments when a fully grown worm is alive and crawling. The single dorsal tooth is relatively smaller than in *S. prolifera* and lies close to the anterior margin of the pharynx.

The proventriculus is long and relatively narrower than in *S. prolifera.*

The end-pieces of the bristles are on the whole longer than those of *S. prolifera* and are much less boldly bifid at the tip. The long end-pieces are continued back to the posterior segments to a much greater degree than in *S. prolifera* and the bifid character does not to the same extent become more marked.

Simple bristles occur in the posterior parapodia as in the former species. Their bifid character is not easy to make out, but some of the bristles seem to show it under a high power of the microscope.

The pigment is brown and the transverse figure of eight pattern described by Grube and subsequent authors is very characteristic on the anterior segments. This pattern is liable to considerable modification, one extreme form of which is described and figured by McIntosh (p. 162, fig. 53). It will be seen that merely by thickening the different bars and dots figured by McIntosh until their ends touch the characteristic *variegata* pattern is produced. The largest specimen of *S. variegata* which I have examined resembles McIntosh's description in colour pattern as well as in all other respects.

The dorsal cirri are moniliform and long, in most cases longer than in *S. prolifera*. In a large specimen the median tentacle contained about 42 articulations, whilst the lateral contained 20. The dorsal cirri along most of the length of the body are alternately long and short ; in the specimen referred to there were 43 articulations in the long cirri and 20 in the short ones. The short cirri are carried by the worm horizontally, whilst the long ones rise vertically and arch over the back, the ends being frequently coiled. The long and short cirri are of nearly uniform diameter throughout, thus differing from *Syllis Krohnii* Ehlers.

SYLLIS (TYPOSYLLIS) KROHNII Ehlers: *McIntosh*, Mon. Brit. Ann. II. 1, 1908, p. 192.

PLYMOUTH. Amongst Corallina from Rum Bay, and from under a stone at Wembury Bay.

Breeding: A specimen from Wembury Bay in March had a well-developed stolon with four red eyes.

TORQUAY. Amongst Corallina from Corbyn's Head (*Elwes*, Journ. M.B.A., vol. 8, 1908, p. 200).

SYLLIS (EHLERSIA) CORNUTA Rathke: *McIntosh*, Mon. Brit. Ann. II. 1, 1908, p. 200.

PLYMOUTH. Eddystone Grounds (*Weldon*, Journ. M.B.A., vol. 5, 1899, p. 481). Occasional specimens which I believe belong to this species have been obtained from dredgings from Duke Rock, Queen's Ground and Asia Shoal, but the identification is not quite certain.

SYLLIS GRACILIS Grube: *McIntosh*, Mon. Brit. Ann. II. 1, 1908, p. 203.

PLYMOUTH. Dredgings from Millbay Channel, Asia Shoal and Queen's Ground. Single specimens frequently met with. Rum Bay shore, from crevices of shale.

SYLLIS (HAPLOSYLLIS) SPONGICOLA Grube: *McIntosh*, Mon. Brit. Ann. II. 1, 1908, p. 197.

PLYMOUTH. Occasional specimens have been found in dredgings from Plymouth Sound (Millbay Channel, Winter Shoal, Cawsand Bay). A considerable number of specimens were obtained from a mass of slimy sponge dredged on the Mewstone Ledge.

SALCOMBE. In dredgings from the channel between Salstone and Snape's Point (Journ. M.B.A., vol. 6, 1900, p. 190).

TORQUAY. Fairly abundant (*Elwes*, Journ. M.B.A., vol. 8, 1908, p. 199).

AMBLYOSYLLIS LINEATA Grube: *McIntosh*, Mon. Brit. Ann. II. 1, 1908, p. 225. *de St. Joseph*, Ann. Sci. Nat. Zool. I. 1886, p. 187 as *Pterosyllis* (*Gattiola*) *spectabilis* Johnston.

PLYMOUTH. Common in dredgings from Millbay Channel: less numerous Queen's Ground, Mallard and Asia Shoal (E.J.A., R.A.T., T.V.H.): sometimes in large numbers in sponges from Millbay Ch. (W.G.). Occurs also amongst Laminaria roots from the shores of the Sound, in dredgings from outside the Breakwater, off Yealm Head and occasionally on Eddystone Grounds.

SALCOMBE. Dredged in the channel west of Salstone (Journ. M.B.A., vol. 6, 1900, p. 190).

TORQUAY. In weeds from rocks between Oddicombe and Babbacombe (*Elwes*, Journ. M.B.A., vol. 8, 1908, p. 199).

It seems probable that Claparède's *Pterosyllis formosa* is the species under consideration. Both McIntosh and de St. Joseph appear to take this view though neither adopts Claparède's name, which has priority.

AUTOLYTUS LONGIFERIENS de St. Joseph: Ann. Sci. Nat. Zool. vol. 1, 1886, p. 217. *McIntosh*, Mon. Brit. Ann. II. 2, 1910, p. 245. *Southern*, Proceed. R. Irish Acad. XXXI. 47, p. 39.

PLYMOUTH. Two specimens were dredged on rocky ground immediately south of the Breakwater in May, one from Duke Rock in June and one was found amongst roots of Laminaria from Rum Bay in June.

The male (*Polybostricus*) and female (*Sacconereis*) forms of this species were obtained in townets near the Eddystone in February. From one Sacconereis kept in the Laboratory the young hatched two weeks after the specimen was procured.

TORQUAY. Five or six specimens were obtained on the shore (*Elwes*, Journ. M.B.A., vol. 8, 1908, p. 202).

AUTOLYTUS RUBROPUNCTATUS (Grube): *Marion and Bobretzky*, Ann. Golfe Marseille, 1875, p. 44 as *Autolytus* (*Procerœa*) *ornatus*. *Southern*, Proceed. R. Irish Acad. XXXI. 47, 1914, p. 40.

PLYMOUTH. Frequent in dredgings from the Sound, Asia Shoal, Queen's Ground and Duke Rock. Frequent also on all the dredging and trawling grounds between Plymouth and the Eddystone and westwards to Looe.

Breeding: No specimens with stolons were found amongst a large number examined between January and June. At the beginning of July, one specimen was seen with a stolon just beginning to form. The observations were interrupted after that month.

Southern has pointed out that the description given by McIntosh (Mon. Brit. Ann. II. 1, p. 186) does not agree with that of other observers. The Plymouth specimens have no ventral cirrus and the setæ have the typical bifid end-pieces of the genus *Autolytus*. McIntosh's coloured figure is stated to be from a Plymouth example.

AUTOLYTUS PICTUS (Ehlers): *McIntosh*, Mon. Brit. Ann. II. 1, 1908, p. 211.

PLYMOUTH. Frequently met with in dredgings from all grounds in Plymouth Sound; especially common amongst *Alcyonidium* and sponges from Asia Shoal. Occasional specimens on all grounds between Plymouth and the Eddystone, especially on rough ground.

Breeding: Three specimens with the Polybostricus head just commencing to form were found in dredgings from Asia Shoal in April.

TORQUAY. Rather common on the shore (*Elwes*, Journ. M.B.A., vol. 8, 1908, p. 201).

AUTOLYTUS MACROPHTHALMA (Marenzeller): *de St. Joseph*, Ann. Sci. Nat. Zool. I. 1886, p. 226. *Southern*, Proc. R. Irish Acad. XXXI. 47, 1914, p. 41.

PLYMOUTH. Specimens have been obtained in dredgings from Millbay Pit, Asia Shoal, New Grounds, Tinker Buoy, and 1 mile off Rame Head.

TORQUAY. Two examples from the shore at Babbacombe (*Elwes*, Journ. M.B.A., vol. 8, 1908, p. 201).

AUTOLYTUS EHBIENSIS de St. Joseph: *McIntosh*, Mon. Brit. Ann. II. 2, 1910, p. 243. *de St. Joseph*, Ann. Sci. Nat. Zool. I. 1886, p. 228.

PLYMOUTH. From Laminaria roots and sea-weeds from the shore at Rum Bay, and amongst Ascidians, etc., from Millbay Dock. Dredged off Yealm Head and near the Eddystone.

Breeding: Specimens with chains of buds in January, in February and in April.

TORQUAY. Found in great abundance on *Fucus*, which was covered with *Sertularia pumila*, on the Breakwater at Babbacombe (*Elwes*, Journ. M.B.A., vol. 8, 1908, p. 201).

AUTOLYTUS PUNCTATUS de St. Joseph: Ann. Sci. Nat. Zool. I. 1886, p. 233.

PLYMOUTH. Not uncommon on Queen's Ground and on the Rame-Eddystone and Looe-Eddystone trawling grounds.

Breeding: Specimens with stolons were taken from May to July. The breeding season probably extends considerably beyond these months.

This species has only been recorded from Dinard by de St. Joseph, from Boulogne by Malaquin (Syllidiens, Lille, 1893, p. 80), and from the west of Ireland by Southern (Proceed. R. Irish Acad. XXXI. 47, 1914, p. 42). It is easily recognised from de St. Joseph's description.

AUTOLYTUS EDWARSI de St. Joseph: Ann. Sci. Nat. Zool. I. 1886, p. 235.

PLYMOUTH. This species is common in dredgings from Duke Rock and the rocky ground immediately south of the Breakwater. It appears to often live in tubes attached to the fronds and roots of Laminaria.

Breeding: Specimens with stolons were found from March to June and the breeding season probably extends beyond these months.

The species, which is well defined, has only been recorded by de St. Joseph from Dinard, by Malaquin (Syllidiens, Lille, 1893, p. 80) from Boulogne, and by Southern (Proceed. R. Irish Acad. XXXI. 47, 1914, p. 43) from the west of Ireland.

AUTOLYTUS PROLIFER (O. F. Müller): *de St. Joseph*, Ann. Sci. Nat. Zool. I. 1886, p. 238. *Langerhans*, Zeits. Wiss. Zool. XXXII. 1879, p. 575.

PLYMOUTH. Two specimens from Millbay Pit dredgings and one from dredgings from the rocky ground south of the Breakwater.

Breeding: Specimen in May had one stolon. In July a female had many eggs in the body segments.

The pharynx has ten large equal teeth, which according to Langerhans and de St. Joseph is characteristic of this species. The body is more robust than that of *A. Edwarsi* or *A. punctatus* and the living worms were picked out as distinct from the other species found here, on account of their form and movements, before the pharynx was examined. I agree with Southern that many of the records of this species in the literature are unreliable.

AUTOLYTUS LUGENS de St. Joseph: Ann. Sci. Nat. Zool. I. 1886, p. 234.

PLYMOUTH. Three or four specimens in dredgings from Queen's Ground and Millbay Pit.

Breeding: In January and February the stolon was just beginning to form; in July a large stolon was well developed.

The specimens agreed with de St. Joseph's description. The massive black tentacles and dorsal cirri of the first segment were very conspicuous. The anal cirri had the same form, and the pharynx has 16 equal teeth. I have found no other record of the species except that by de St. Joseph, who took it at Dinard.

AUTOLYTUS INERMIS de St. Joseph: Ann. Sci. Nat. Zool. I. 1886, p. 237.

PLYMOUTH. Occasional specimens have been taken on the principal dredging grounds in the Sound, as well as on the trawling grounds between Plymouth and the Eddystone and Eddystone and Looe. The specimens all had the characteristic colour.

Breeding: With stolons in December, January, April, May and June. One specimen in August had no stolon.

TORQUAY. One specimen (*Elwes*, Journ. M.B.A., vol. 8, 1908, p. 202). Malaquin (Syllidiens, Lille, 1893, p. 76) makes a new genus, *Autolytides* for this species, in which the pharynx has a plain border, without teeth of any kind.

MYRIANIDA PINNIGERA (Montagu): *McIntosh*, Mon. Brit. Ann. II. 1, 1908, p. 229. *Malaquin*, Syllidiens, Lille, 1893, Plate I, etc., as *M. fasciata* Milne-Edwards.

PLYMOUTH. Frequently met with in Plymouth Sound (W.G.); dredgings from Millbay Channel, Asia and Queen's Ground (T.V.H., R.A.T., E.J.A.); amongst Ascidians and sponges from the piles at Millbay Dock (R.A.T., E.J.A.).

SALCOMBE. On the shore at the Salstone and dredged in the channel to the west of the Salstone (Journ. M.B.A., vol. 6, 1900, p. 190).

PROCERASTEA HALLEZIANA Malaquin: Recherches sur les Syllidiens, Lille, 1893, p. 81, Pl. XI. Figs. 1–14, Pl. VIII. Fig. 26.

PLYMOUTH. Six specimens were obtained from amongst Ascidians from a raft moored in Cawsand Bay, September 30th, 1914.

Breeding: The specimens bore no stolons, but in one specimen three of the middle segments were considerably enlarged.

HESIONIDÆ.

MAGALIA PERARMATA Marion and Bobretzky: Annél. Golfe Marseille, 1875, p. 54. *McIntosh*, Mon. Brit. Ann. II. 1, 1908, p. 136.

PLYMOUTH. Not uncommon in dredgings from Millbay Channel, Asia Shoal, Queen's Ground and Duke Rock. From trawl material, Rame-Eddystone ground. From scrapings from piles at Millbay Dock.

TORQUAY. Common among Laminaria roots (*Elwes*, Journ. M.B.A., vol. 8, 1908, p. 350).

OXYDROMUS PROPINQUUS Marion and Bobretzky: Annél. Golfe Marseille, 1875, p. 51, as *Gyptis propinqua*. *de St. Joseph*, Ann. Sci. Nat. Zool. V. 1887, p. 321.

PLYMOUTH. Not uncommon in dredgings from near New Grounds Buoy from January to April.

Breeding: Females with well-developed eggs, January to April.

OPHIODROMUS FLEXUOSUS Delle Chiaje: *McIntosh*, Mon. Brit. Ann. II. 1, 1908, p. 117.

PLYMOUTH. Three or four specimens have been obtained from the Looe-Eddystone trawling grounds.

CASTALIA PUNCTATA (O. F. Müller): *McIntosh*, Mon. Brit. Ann. II. 1, 1908, p. 121.

PLYMOUTH. Common in dredgings from Millbay Channel and Asia Shoal; occasionally from Duke Rock and Queen's Ground. A few specimens from rough grounds outside the Sound, e.g. 2 miles off Yealm Head and 2 miles S.W. by W. of Eddystone.

It was taken by Crawshay 17·5 miles S. 25° W. of the Eddystone in 42 fathoms (Journ. M.B.A., vol. 9, 1912, p. 340).

CASTALIA FUSCA (Johnston): *McIntosh*, Mon. Brit. Ann. II. 1, 1908, p. 127.

PLYMOUTH. On the shore under stones and amongst the roots of weeds from Drake's Island, Rum Bay and Mount Edgcumbe; from the piles at Millbay Dock. Amongst dredgings from Millbay Channel and Asia Shoal. Recorded in the previous list as *Kefersteinia cirrata* (Keferstein).

TORQUAY. Common under stones, especially at Meadfoot; also in Laminaria roots (*Elwes*, Journ. M.B.A., vol. 8, 1909, p. 350).

AMPHINOMIDÆ.

SPINTHER MINIACEUS Grube: *McIntosh*, Mon. Brit. Ann. I. 2, 1900, p. 232.

PLYMOUTH. Half a dozen specimens living on a sponge dredged at Duke Rock, February 6th, 1906.

Breeding: Ripe females, depositing eggs.

EUPHROSYNE FOLIOSA Audouin and Edwards: *McIntosh*, Mon. Brit. Ann. I. 2, 1900, p. 234.

PLYMOUTH. Occasional specimens in dredgings from Queen's Ground, Asia Shoal and Millbay Channel (T.V.H., R.A.T., E.J.A.). Eddystone Grounds.

One specimen 40 miles S. 24° W. of Eddystone in 49 fms. (*Crawshay*, Journ. M.B.A., vol. 9, 1912, p. 341).

EXMOUTH. One specimen dredged amongst sponges (Journ. M.B.A., vol. 6, 1902, p. 318).

APHRODITIDÆ.

APHRODITA ACULEATA Linn.: *McIntosh*, Mon. Brit. Ann. I. 2, 1900, p. 247.

PLYMOUTH. On most of the fine-sand grounds off Plymouth, between 20 and 30 fms. (T.V.H., R.A.T., E.J.A.) S.S.W. of the Eddystone to 42 fms. (*Crawshay*, Journ. M.B.A., vol. 9, 1912, p. 340).

SALCOMBE. One small specimen from Millbay Sands (Journ. M.B.A., vol. 6, 1900, p. 190).

TORQUAY. Thrown up on shore after heavy weather, especially at Anstey Cove and Tor Abbey Sands (*Elwes*, Journ. M.B.A., vol. 9, 1910, p. 59).

HERMIONE HYSTRIX (Savigny): *McIntosh*, Mon. Brit. Ann. I. 2, 1900, p. 264.

PLYMOUTH. Most frequently on gravel grounds in the neighbourhood of the Eddystone (*Hodgson*, Journ. M.B.A., vol. 6, 1900, p. 240): occasionally on similar ground in about 20 fms. (R.A.T., E.J.A.).

S.S.W. of the Eddystone to 50 fms. on rough ground (*Crawshay*, Journ. M.B.A., vol. 9, 1912, p. 340).

LEPIDONOTUS SQUAMATUS (Linn.): *McIntosh*, Mon. Brit. Ann. I. 2, 1900, p. 274.

PLYMOUTH. Under stones and amongst weeds, Hydroids, Polyzoa, etc.: from low-tide mark to 30 fms. and over, common and widely distributed (*Hodgson*, Journ. M.B.A., vol. 6, 1900, p. 240).

S.S.W. of the Eddystone to 42 fms. (*Crawshay*, Journ. M.B.A., vol. 9, 1912, p. 340).

SALCOMBE. Dredged in the channel between the Salstone and Snape's Point, as well as in the channel in Salcombe Harbour. It was also obtained under the Marine Hotel (*Hodgson*, Journ. M.B.A., vol. 6, 1900, p. 190).

TORQUAY. Two or three under stones on Babbacombe Beach (*Elwes*, Journ. M.B.A., vol. 9, 1910, p. 59).

LEPIDONOTUS CLAVA (Montagu): *McIntosh*, Mon. Brit. Ann. I. 2, 1900, p. 280.

PLYMOUTH. Everywhere on the shore under stones, especially at extreme low water (*Hodgson*, Journ. M.B.A., vol. 6, 1900, p. 241): less frequently in dredgings from the Sound.

EXMOUTH. Not uncommon on the shore at Orcombe Rocks (Journ. M.B.A., vol. 6, 1902, p. 318).

TORQUAY. Occasionally found on all the beaches. Numerous specimens on a large buoy in Torquay Harbour (*Elwes*, Journ. M.B.A., vol. 9, 1910, p. 59).

GATTYANA CIRROSA (Pallas): *McIntosh*, Mon. Brit. Ann. I. 2, 1900, p. 285.

PLYMOUTH. In dredgings from the neighbourhood of the Eddystone (*Hodgson*, Journ. M.B.A., vol. 6, 1900, p. 242). Yealm Sand Bank and east shore, commensal in tubes of *Amphitrite Johnstoni*.

SALCOMBE. Found on the shore living in the tubes of *Amphitrite Johnstoni* on the Salstone, south of Halwell Point and near the mouth of Salcombe Harbour (under Marine Hotel) (*Hodgson*, Journ. M.B.A., vol. 6, 1900, p. 190).

EUNOA NODOSA (M. Sars): *McIntosh*, Mon. Brit. Ann. I. 2, 1900, p. 291.

One specimen from the stony ground off Prawle Point, in 30 fms. (*Weldon*, Journ. M.B.A., vol. 5, 1899, p. 478).

LAGISCA EXTENUATA (Grube): *Fauvel*, Résult. Camp. Sci. Monaco. Fas. XLVI. Annél. Polych. 1914, p. 62. *McIntosh*, Mon. Brit. Ann. I. 2, 1900, p. 298 as *L. floccosa* (Savigny) = *L. propinqua* Malmgren.

PLYMOUTH. Between tide-marks and in dredgings throughout the whole area to 30 fms. (*Hodgson*, Journ. M.B.A., vol. 6, 1900, p. 247 as *L. floccosa*. At many stations S.S.W. of the Eddystone to about 50 fms. (*Crawshay*, Journ. M.B.A., vol. 9, 1912, p. 340, as *L. floccosa*).

TORQUAY. Fairly common under stones (*Elwes*, Journ. M.B.A., vol. 9, 1910, p. 59).

NOTE. Two varieties of this species occur in the Plymouth district. (1) A littoral and inshore variety, in which the elytron bears on its edge a few minute scattered cilia only, whilst the surface is covered with small tubercles slightly conical in shape and of fairly uniform size (a few being slightly larger than the rest) and has a number of large, brown, globular papillæ near the posterior border. (2) A deeper water variety found on the dredging and trawling grounds from 20 to 50 fms., in which the elytra bear on their edges a continuous row of minute cilia, almost spherical in shape. The surface of the elytron is covered with small tubercles as in the littoral variety, but scattered over the surface both towards the centre and especially towards the exterior and posterior borders a number of the tubercles are greatly enlarged, so that they stand out as strong conical spines. Those near the posterior border are the largest and their ends may appear rounded and swollen, but they do not attain the size of the large globular papillæ of the littoral form. This deeper water form approaches the *L. rarispina* of Malmgren, and was so entered in our previous lists. The spines do not, however, attain the length indicated in Malmgren's figures (Nordiska Hafs-Annulater, 1865. Tafl. VIII. figs. 2 and 2c).

With regard to the name of the species, Fauvel (*loc. cit.*) points out that Savigny's *L. floccosa* is described by its author as having sixteen pairs of elytra, and his description is too incomplete to fix even the genus to which it belongs. The first recognisable description of the present form is by Grube with the specific name *extenuata*. By this name it has been generally referred to in the literature or by its later synonym *L. propinqua* Malmgren.

The species referred to in previous lists by Hodgson and Elwes from Plymouth and Torquay (*loc. cit.*) as *L. extenuata* Grube, is I believe *L. Elisabethæ* McIntosh.

LAGISCA ELISABETHÆ McIntosh : Mon. Brit. Ann. I. 2, 1900, p. 303.

PLYMOUTH. On the shore at Wembury Bay and Rum Bay, not uncommon. Probably the form referred to by Hodgson (Journ. M.B.A., vol. 6, 1900, p. 247) as *L. extenuata* Grube.

TORQUAY. Very common in roots of Laminaria and under stones (*Elwes*, Journ. M.B.A., vol. 9, 1910, p. 59). Southern has examined specimens from Torquay sent by Major Elwes and states that they are certainly this form (Proceed. R. Irish Acad. XXXI, 47, 1914, p. 51).

HARMOTHOË IMBRICATA (Linn.) : *McIntosh*, Mon. Brit. Ann. I. 2, 1900, p. 314.

PLYMOUTH. Between tide-marks amongst Laminaria roots on the Breakwater : amongst Hydroids, Polyzoa, etc., on Eddystone Grounds (*Hodgson*, Journ. M.B.A., vol. 6, 1900, p. 245).

This form seems to be rare at Plymouth, and I have not succeeded in re-finding it.

HARMOTHOË SPINIFERA (Ehlers) : *McIntosh*, Mon. Brit. Ann. I. 2, 1900, p. 327.

PLYMOUTH. Amongst dredgings from Millbay Channel, Queen's Ground, Asia Shoal, etc., and Yealm River : common (T.V.H., R.A.T., E.J.A.).

SALCOMBE. Dredged in the channel west of the Salstone, and between the Salstone and Snape's Point (*Hodgson*, Journ. M.B.A., vol. 6, 1900, p. 190).

TORQUAY. One specimen only found (*Elwes*, Journ. M.B.A., vol. 9, 1910, p. 59).

HARMOTHOË LUNULATA (Delle Chiaje) : *McIntosh*, Mon. Brit. Ann. I. 2, 1900, p. 342.

PLYMOUTH. A not uncommon tidal form. Found among roots of Laminaria on the Breakwater, and occasionally under stones near low water (*Hodgson*, Journ. M.B.A., vol. 6, 1900, p. 243). One specimen S.S.W. of Eddystone in 49 fms. (*Crawshay*, Journ. M.B.A., vol. 9, 1912, p. 341).

SALCOMBE. On the shore of the bay north of Pilworthy Point (*Hodgson*, Journ. M.B.A., vol. 6, 1900, p. 190).

HARMOTHOË SETOSISSIMA (Savigny): *McIntosh*, Mon. Brit. Ann. I. 2, 1900, p. 345.

PLYMOUTH. Occasionally found among Polyzoa (*Cellaria*) and *Chætopterus* tubes from the Eddystone Grounds (*Hodgson*, Journ. M.B.A., vol. 6, 1900, p. 244). S.S.W. of the Eddystone in 43–49 fms. (*Crawshay*, Journ. M.B.A., vol. 9, 1912, p. 341).

SALCOMBE. On the eastern shore of Salcombe Harbour (*Hodgson*, Journ. M.B.A., vol. 6, 1900, p. 190).

HARMOTHOË AREOLATA (Grube): *McIntosh*, Mon. Brit. Ann. I. 2, 1900, p. 349.

PLYMOUTH. Not uncommon on the Eddystone Grounds, where the dredge or trawl brings up masses of Polyzoa, Hydroids and *Chætopterus* tubes (*Hodgson*, Journ. M.B.A., vol. 6, 1900, p. 244).

HARMOTHOË FRASER-THOMSONI McIntosh: Mon. Brit. Ann. I. 2, 1900, p. 337.

PLYMOUTH. Two specimens S.S.W. of the Eddystone in 49–51 fms. (*Crawshay*, Journ. M.B.A., vol. 9, 1912, p. 341).

HARMOTHOË MARPHYSÆ McIntosh: Mon. Brit. Ann. I. 2, 1900, p. 339.

PLYMOUTH. Prof. McIntosh records this species from the galleries of *Marphysa sanguinea* from chinks in the rocks, Polperro (British Museum). It was found at Plymouth by Mr. R. A. Todd commensal with *Marphysa sanguinea* on the shore at Mount Edgcumbe.

A form which seems to resemble *H. marphysæ* more closely than any other described species has been met with in fine sand in the Yealm Estuary. In one case the sand contained *Amphitrite Johnstoni*, in another *Synapta inhærens*, and a definite association of the *Harmothoë* with the *Synapta* was actually observed in one instance.

ERARNE IMPAR (Johnston): *McIntosh*, Mon. Brit. Ann. I. 2, 1900, p. 353.

PLYMOUTH. Common between tide-marks and amongst dredgings throughout the Plymouth area (T.V.H., E.J.A.): Eddystone Grounds (T.V.H.). S.S.W. of Eddystone in 40–42 fms. (*Crawshay*, Journ. M.B.A., vol. 9, 1912, p. 341).

SALCOMBE. Dredged in the channel between the Salstone and the mouth of Salcombe Harbour (*Hodgson*, Journ. M.B.A., vol. 6, 1900, p. 190).

EXMOUTH. On the shore west of the mouth of Salthouse Lake (Journ. M.B.A., vol. 6, 1902, p. 318).

TORQUAY. Rare. Recorded by Gosse from Anstey's Cove (*Elwes*, Journ. M.B.A., vol. 9, 1910, p. 59).

SCALISETOSUS COMMUNIS (Delle Chiaje): *McIntosh*, Mon. Brit. Ann. I. 2, 1900, p. 372.

PLYMOUTH. On the shore at Mount Edgcumbe: amongst dredgings Millbay Channel and Asia Shoal (R.A.T., E.J.A.).

Fauvel considers that the name *S. pellucidus* (Ehlers) should be maintained for this species, as there is great doubt as to Delle Chiaje's species (Camp. Sci. Monaco, XLVI. 1914, p. 47).

SCALISETOSUS ASSIMILIS (McIntosh): *McIntosh*, Mon. Brit. Ann. I. 2, 1900, p. 377.

PLYMOUTH. Among spines of *Echinus esculentus* from Mewstone and Eddystone Grounds (T.V.H., R.A.T., E.J.A.).

MALMGRENIA CASTANEA, McIntosh: Mon. Brit. Ann. I. 2, 1900, p. 379.

PLYMOUTH. Commensal on the surface of *Spatangus purpureus*, near the mouth of the Echinoderm: not uncommon (T.V.H., E.J.A.).

HALOSYDNA GELATINOSA (M. Sars): *McIntosh*, Mon. Brit. Ann. I. 2, 1900, p. 384.

PLYMOUTH. Frequently met with on the shore under stones and amongst dredging and trawling material throughout the area, including the Eddystone Grounds.

One specimen taken by Crawshay S.S.W. of the Eddystone in 49 fms. (Journ. M.B.A., vol. 9, 1912, p. 341).

TORQUAY. One specimen under a stone at Babbacombe Beach (*Elwes*, Journ. M.B.A., vol. 9, 1910, p. 60).

POLYNOE SCOLOPENDRINA Savigny *Auct.*: *McIntosh*, Mon. Brit. Ann. I. 2, 1900, p. 389. *Marenzeller*, Zur Kenntniss der adriatischen Anneliden. Sitzb. math-nat. Cl. Wien. 69, 1874, p. 420 as *P. Johnstoni*.

PLYMOUTH. Commensal in tubes of *Polymnia nebulosa* on the shore at Mount Edgcumbe. In dredgings from Asia Shoal.

Eddystone Grounds (*Hodgson*, Journ. M.B.A., vol. 6, 1900, p. 249).

The specimens commensal with *Polymnia nebulosa* are large (6 to 7 centimetres long) and the colour tends, especially in spirit, to dark olive green. Those from dredgings in the Sound are smaller (2–3 cm.) and the colour is light brown. The elytra of the two sides nearly or even quite meet in the middle line in both cases. The dorsal bristle bundles are well developed. Three rows of dorsal tubercles on the posterior segments are very marked.

POLYNOE CRASSIPALPA Marenzeller: Zur Kenntniss der adriatischen Anneliden. Sitzb. math-nat. Cl. Wien. 69, 1874, p. 412.

PLYMOUTH. Occasional specimens are met with in dredgings from Plymouth Sound.

When the two are seen side by side there can be no doubt that

Marenzeller was right in separating this form from the *P. scolopendrina* Savigny of Johnston and other authors. In *P. crassipalpa* the body is much more slender and the dorsum is more strongly pigmented, the dark brown colour being arranged in a characteristic pattern. The posterior part of the ventral surface is also strongly pigmented. The elytra are small, to quote Savigny "separated by an interval equal to their breadth, the two rows thus leaving all the middle of the back uncovered; but the elytra of each row mutually overlap a little" (Syst. des Annélides, p. 25). This character and the complete absence of tubercles on the uncovered, posterior part of the dorsum give the species a quite characteristic appearance to the naked eye or under a low power lens. The bristles of the dorsal bundle in the typical foot are few, two or three only in one specimen examined by me, six in Marenzeller's specimens, and spinous rows are little developed on them. The ventral bristles as well as other details of the worm are well described by Marenzeller. The latter author, however, in my opinion, attaches undue importance in distinguishing the species of this genus to the relative lengths of the median tentacle, palps and tentacular cirri, especially as these have apparently been noted both by himself and by other authors only on preserved specimens. The palps especially seem to be subject to considerable and very variable degrees of contraction under the influence of preservatives. In a well preserved specimen which shows little sign of contraction I find the median tentacle just a little longer than the palps, and the dorsal tentacular cirri about the same length as the median tentacle. The palps taper gradually to a point and are not shaped as in Marenzeller's figure, which seems to have been drawn from a specimen in which they were much contracted.

Although I have not much doubt that Savigny's description applies to the present species it is impossible to be quite certain on the point, and it therefore seems better to use *P. scolopendrina* for the other form, which has been known under that name for half a century, and to call the present one *P. crassipalpa*, the name under which it was first clearly described by Marenzeller.

LEPIDASTHENIA ARGUS Hodgson: Journ. M.B.A., vol. 6, 1900, p. 250.

SALCOMBE. Found in the tubes of *Amphitrite Edwardsi*, on the shore between Salcombe town and Sandhill Point (under Marine Hotel) (T.V.H.).

The species has since been taken on many occasions in the same locality and under the same conditions as originally described by Hodgson. It has never been found elsewhere.

ACHOLOË ASTERICOLA (Delle Chiaje): *McIntosh*, Mon. Brit. Ann. I. 2, 1900, p. 397.

In the ambulacral groove of *Astropecten irregularis*: common (T.V.H., R.A.T., E.J.A.).

STHENELAIS BOA (Johnston): *McIntosh*, Mon. Brit. Ann. I. 2, 1900, p. 408.

PLYMOUTH. Common in sand between tide-marks, Rum Bay, Drake's Island, Mount Edgcumbe, Wembury Bay, Yealm River (T.V.H., R.A.T., E.J.A.): occasionally amongst dredgings from Millbay Channel and Asia Shoal (T.V.H., E.J.A.): Mewstone Grounds (T.V.H.).

SALCOMBE. On the Salstone and near the mouth of the harbour, between the Ferry House and Millbay; never numerous. Dredged in the channel between Salstone and Snape's Point (Journ. M.B.A., vol. 6, 1900, p. 191).

EXMOUTH. One specimen in the channel; never met with on the shore (Journ. M.B.A., vol. 6, 1902, p. 318).

TORQUAY. Not uncommon in the sand at Tor Abbey Sands (*Elwes*, Journ. M.B.A., vol. 9, 1900, p. 60).

STHENELAIS LIMICOLA, Ehlers: *McIntosh*, Mon. Brit. Ann. I. 2, 1900, p. 417.

PLYMOUTH. One specimen in a coarse townet attached to the Otter-trawl, 5 miles W.S.W. of Rame Head. One specimen dug in the sand bank in the upper part of the Yealm River.

SIGALION MATHILDÆ Audouin and Edwards: *McIntosh*, Mon. Brit. Ann. I. 2, 1900, p. 427.

TEIGNMOUTH. One specimen obtained in the sand below Shaldon Bridge.

PHOLOË MINUTA (Fabricius): *McIntosh*, Mon. Brit. Ann. I. 2, 1900, p. 437.

PLYMOUTH. Common amongst dredging and trawling material over the whole Plymouth area, including Eddystone Grounds. Especially abundant in Millbay Channel and on Asia Shoal.

TORQUAY. The most numerous of all the Torquay Aphroditidæ, inhabiting especially the Laminarian zone (*Elwes*, Journ. M.B.A., vol. 9, 1910, p. 60).

PHYLLODOCIDÆ.

NOTOPHYLLUM FOLIOSUM (Sars): *McIntosh*, Mon. Brit. Ann. II. 1, 1908, p. 46.

PLYMOUTH. Frequent in dredgings from all the grounds in the Sound, and often met with on all the dredging and trawling grounds outside, including the Eddystone Grounds.

In the previous list this species was wrongly named *Eulalia obtecta* Ehlers.

TORQUAY. One from Livermead (*Elwes*, Journ. M.B.A., vol. 8, 1909, p. 349).

EULALIA BILINEATA (Johnston): *McIntosh*, Mon. Brit. Ann. II. 1, 1908, p. 51.

PLYMOUTH. Frequent amongst dredgings from the Sound, especially from Millbay Channel and Asia Shoal. Dredged off Yealm Head. Amongst roots of Laminaria from Cawsand Bay.

EULALIA AUREA Gravier: Recherches sur les Phyllodociens, Bull. Sci. France et Belg. XXIX. 1896, p. 309.

PLYMOUTH. Common on all the dredging grounds in Plymouth Sound. Occasional specimens are met with on most of the grounds near shore, e.g. off Yealm Head.

McIntosh (Mon. Brit. Ann. II. 1, 1908, p. 60) regards *E. aurea* as a variety of *E. viridis*. The general shape of the animal, the character of its movements, its size when mature and its usual habitat seem to mark it clearly from that form. The most striking difference is, however, the distinctive colour and colour pattern of each of the forms, which is very constant. In most respects *E. aurea* seems nearer to *E. bilineata* than to *E. viridis*.

Breeding: With eggs January to July (R.A.T., E.J.A.).

TORQUAY. On the shore, but not above the Laminarian zone (*Elwes*, Journ. M.B.A., vol. 8, 1909, p. 348).

EULALIA ORNATA de St. Joseph: Ann. Sci. Nat. Zool. V. 1888, p. 291.

PLYMOUTH. In dredgings from the Sound, especially Millbay Channel and Asia Shoal. Much less frequent than *E. aurea*.

McIntosh (Mon. Brit. Ann. II. 1, 1908, p. 59) regards this form also as a variety of *E. viridis*. The well-marked colour pattern, its general shape and the character of its movements appear to me to justify doubts as to this conclusion.

TORQUAY. Fairly common, but not above the Laminarian zone (*Elwes*, Journ. M.B.A., vol. 8, 1909, p. 347).

EULALIA VIRIDIS (O. F. Müller): *McIntosh*, Mon. Brit. Ann. II. 1, 1908, p. 55.

PLYMOUTH. Common on rocky shores in the Sound and on the coast. Its usual home seems to be amongst shore sea-weeds, to which the large gelatinous masses of green eggs are attached. It is, however, occasionally taken in dredgings from the Sound, especially in an immature state, and specimens have even been taken on the Eddystone Grounds.

Breeding: Eggs in January and February; abundant in May and June. None found at end of July or in August (A.J.S.).

SALCOMBE. From dredgings between Salstone and Snape's Point (Journ. M.B.A., vol. 6, 1900, p. 193).

EXMOUTH. Two specimens were obtained from Orcombe Rocks, at the mouth of the estuary (Journ. M.B.A., vol. 6, 1902, p. 320).

TORQUAY. Particularly abundant where the limestone rocks have been much eaten away from about half-tide mark downwards. It appears to like crawling about the damp rocks out of the water when the tide is low (*Elwes*, Journ. M.B.A., vol. 8, 1909, p. 347).

Eulalia tripunctata McIntosh : Mon. Brit. Ann. II. 1, 1908, p. 63. *de St. Joseph*, Ann. Sci. Nat. Zool. V. 1888, p. 285, as *E. Claparedii.*

Plymouth. Not infrequent in dredgings from Millbay Channel, Asia Shoal and occasionally Queen's Ground and Duke Rock. Found also on the outer grounds, e.g. off Yealm Head. Cawsand Bay, among Laminaria roots from the shore. Recorded in the former list as *E. Claparèdi.*

Breeding : May, eggs brick-red.

Eulalia punctifera (Grube) : *McIntosh*, Mon. Brit. Ann. II. 1, 1908, p. 53 as *Eulalia nebulosa*, Montagu.

Plymouth. In dredgings from Millbay Channel, Asia Shoal and Yealm ; on the shore at Mount Edgcumbe and in the Yealm Estuary.

Salcombe. Dredged in the channel between the Salstone and Snape's Point (Journ. M.B.A., vol. 6, 1900, p. 193).

Torquay. One specimen from Corbyn's Head (*Elwes*, Journ. M.B.A., vol. 8, 1909, p. 348).

Eulalia (Pterocirrus) macroceros (Grube) : *McIntosh*, Mon. Brit. Ann. II. 1, 1908, p. 60.

Plymouth. Occasional specimens from dredging grounds in the Sound. A number also taken in dredging from 2 miles off Yealm Head.

Eulalia (Eumida) sanguinea Oersted : *McIntosh*, Mon. Brit. Ann. II. 1, 1908, p. 66.

Plymouth. Common and generally distributed in dredging material throughout the area, especially in inshore waters. Frequent amongst Laminaria roots from the shore.

Breeding : May to July ; eggs green, occasionally reddish.

The species shows considerable variety both of form and colour, and it seems probable that McIntosh has included under this name several forms which may prove to be distinct species.

One variety with alternate green and white bands on the dorsum (*Eulalia* Sp. B. *McIntosh, l.c.*, p. 68), when seen alive appears to be specially distinct. Southern (Proceed. R. Irish Acad. XXXI. 47, 1914, p. 66) has also found this variety on the west coast of Ireland.

In the former list the present species was entered under the name of *Eulalia pallida* Claparède, with a reference to de St. Joseph's description.

Torquay. Common among Laminaria roots (*Elwes*, Journ. M.B.A., vol. 8, 1909, p. 348).

Phyllodoce lamelligera (Gmelin) : *McIntosh*, Mon. Brit. Ann. II. 1, 1908, p. 76.

Between tide-marks Drake's Island: Breakwater: in dredgings from Millbay Channel, Asia Shoal, Duke Rock (T.V.H., E.J.A.).

Recorded in the former list as *P. laminosa*, Savigny.

TORQUAY. One light coloured individual under a stone at Hope's Nose, and another of normal colouring at Meadfoot (*Elwes*, Journ. M.B.A., vol. 8, 1909, p. 349).

PHYLLODOCE PARETTI (Blainville): *McIntosh*, Mon. Brit. Ann. II. 1, 1908, p. 82.

PLYMOUTH. Occasional specimens in dredgings from the Mewstone Ledge (E.J.A.): off Stoke Point (S.P.).

TORQUAY. The head and about twenty segments of one from Corbyn's Head (*Elwes*, Journ. M.B.A., vol. 8, 1909, p. 349).

PHYLLODOCE MACULATA (Linn.): *McIntosh*, Mon. Brit. Ann. II. 1, 1908, p. 89.

PLYMOUTH. Common in dredgings from the Sound and inshore waters, being sometimes present in very large numbers. It seems to be much more abundant during the summer months than in winter. Large specimens which seem to be the same species were found in fine clean sand at Wembury Bay.

Breeding. January, February (W.G.): April to July. Eggs orange-brown or green (E.J.A.).

EXMOUTH. A form recorded as *P. teres* Malmgren from fine clean sand at Exmouth and from similar ground at Teignmouth I am now inclined to regard as the common *P. maculata* (Journ. M.B.A., vol. 6, 1902, p. 319).

TORQUAY. Common between tide-marks. Found amongst rocks and weeds, and also in the sand (*Elwes*, Journ. M.B.A., vol. 8, 1909, p. 348).

PHYLLODOCE RUBIGINOSA de St. Joseph: *McIntosh*, Mon. Brit. Ann. II. 1, 1908, p. 92.

PLYMOUTH. Frequent in dredgings from Millbay Channel, Asia Shoal and other parts of the Sound. Amongst dredge and trawl material from near the Eddystone.

Crawshay obtained several specimens S.S.W. of the Eddystone in 46–49 fms. (Journ. M.B.A., vol. 9, 1912, p. 341).

ETEONE PICTA Quatrefages: *McIntosh*, Mon. Brit. Ann. II. 1, 1908, p. 100.

PLYMOUTH. Occasional specimens from dredgings, Millbay Channel, Asia Shoal, Queen's Ground, Barn Pool. Some large specimens were found amongst roots of Laminaria from the shore at Cawsand Bay, and it was also taken on the shore at Wembury Bay.

TORQUAY. Small ones not uncommon amongst Laminaria roots (*Elwes*, Journ. M.B.A., vol. 8, 1909, p. 349).

ETEONE PUSILLA Oersted (*nec* Malmgren): *Oersted*, Ann. Dann. Consp. 1843, p. 30. *Michaelsen*, Poly. deutsch. Meere., Wiss. Meeresunters. II, 1897, p. 37.

EXMOUTH. In clean fine sand in the estuary (Journ. M.B.A., vol. 6, 1902, p. 319–320). Specimens 17 to 18 mm. long, one of 17·5 mm. having 94 pairs of parapodia.

TEIGNMOUTH. In clean fine sand in the estuary.

The head exactly resembles Oersted's figure. The anal cirri are large and swollen. They vary from cylindrical with a rounded end to slightly pear-shaped in preserved specimens, and very slight contraction in the preserving fluid would justify Oersted's description "papillis caudalibus subglobosis." They are altogether different from those figured by Malmgren, and from his description "cirri anales lineare-fusiformes elongati" (Nord. Hafs. Ann., 1865, p. 102, Tab. XV. Fig. 37).

MYSTIDES LIMBATA de St. Joseph: Ann. Sci. Nat. Zool. V. 1887, p. 310.

PLYMOUTH. Dredged off the Mewstone in 15–16 fms. Female with dark green eggs in May (J.T.C.).

Not uncommon in dredgings from Asia Shoal and Queen's Ground (New Grounds). In dredgings from Yealm River.

A small median tentacle, as in *Eulalia*, is very distinct in some specimens when alive, but in the majority of specimens it is difficult, if not impossible to make out. In all other respects the form agrees with de St. Joseph's description.

TOMOPTERIDÆ.

TOMOPTERIS HELGOLANDICA Greef: *Apstein*, Alciopiden und Tomopteriden der Plankton-Expedition, Kiel, 1900.

PLYMOUTH. Not uncommon in townettings from the Channel.

NEREIDÆ.

MICRONEREIS VARIEGATA Claparède: *McIntosh*, Mon. Brit. Ann. II. 2, 1910, p. 261. *Regnard*, Mém. Soc. Zool. de France, XXVI. 1913, p. 91.

PLYMOUTH. Amongst weeds and Corallina from the shore at Rum Bay. From weeds dredged in Cawsand Bay.

TORQUAY. Amongst red algæ and Lithothamnion from the rocks between Oddicombe and Babbacombe beaches (*Elwes*, Journ. M.B.A., vol. 8, 1909, p. 350).

LEPTONEREIS GLAUCA Claparède: *Ramsay*, Journ. M.B.A. vol. 10, 1914, p. 244.

PLYMOUTH. From the piles of the wharf at Millbay Docks. Fairly numerous. Heteronereid males in February, females filled with ova in March (*Ramsay, l.c.*).

TORQUAY. One male Heteronereid in February at Oddicombe (*Elwes*, Journ. M.B.A., vol. 8, 1909, p. 351 as *L. Vaillanti*).

NEREIS PELAGICA Linnæus: *McIntosh*, Mon. Brit. Ann. II. 2, 1910, p. 267.

PLYMOUTH. Frequent amongst weeds on rocky shores and from dredgings in all parts of the Sound; also Wembury Bay and Yealm River (T.V.H., E.J.A.).

EXMOUTH. Dredged amongst masses of sponge (*Halichondria panicea*) in the main channel (Journ. M.B.A., vol. 6, 1902, p. 318).

TORQUAY. Extremely common in the roots of Laminaria. Heteronereids in January and February (*Elwes*, Journ. M.B.A., vol. 8, 1909, p. 351).

NEREIS ZONATA Malmgren: *Fauvel*, Résult. Camp. Sci. Monaco, Fas. XLVI. Annél. Polych. 1914, p. 177.

PLYMOUTH. Common on the dredging and trawling grounds off Plymouth in depths of from 20–40 fms. Recorded previously as *N. procera* Ehlers (Journ. M.B.A., vol. 5, 1899, p. 481).

Dredged by Crawshay S.S.W. of the Eddystone in depths of 42–49 fms. (Journ. M.B.A., vol. 9, 1912, p. 342 as *N. pelagica*).

It seems to me probable that this is the species which Johnston calls *Nereis fimbriata* O. F. Müller. He states that it inhabits the "coralline region," and he obtained it not only at Berwick Bay but also from Polperro (Cat. Worms. Brit. Mus. 1865, pp. 155 and 341).

NEREIS (PERINEREIS) CULTRIFERA Grube: *McIntosh*, Mon. Brit. Ann. II. 2, 1910, p. 280.

PLYMOUTH. Common on the shores all around the Sound, Wembury Bay, Yealm Estuary, especially in muddy gravel. Young specimens frequent in dredgings.

SALCOMBE. Common all round the estuary excepting in very fine mud. Most common where soil is gravel mixed with sand and mud (Journ. M.B.A., vol. 6, 1900, p. 192).

EXMOUTH. One specimen only was found at Orcombe Rocks, quite at the mouth of the estuary (Journ. M.B.A., vol. 6, 1902, p. 318).

TORQUAY. Under stones, not very common, on the edge of the submerged forest at Tor Abbey Sands (*Elwes*, Journ. M.B.A., vol. 8, 1909, p. 352).

NEREIS (PERINEREIS) MARIONI Audouin and Edwards: *McIntosh*, Mon. Brit. Ann. II. 2, 1910, p. 295.

PLYMOUTH. McIntosh (*loc. cit.*) records this species from Plymouth, probably in material sent from the Laboratory. I have not yet found it myself.

NEREIS (PRAXITHEA) SCHMARDÆI Quatrefages : *McIntosh*, Mon. Brit. Ann. II. 2, 1910, p. 291. *de St. Joseph*, Ann. Sci. Nat. Zool. V. 1888, p. 263, and XX. 1895, p. 215 as *N. irrorata* Malmgren.

PLYMOUTH. Not uncommon in coarse sand and gravel between tide-marks, Drake's Island, Mount Edgcumbe, Jennycliff (rare), Wembury Bay, Yealm Estuary south shore. Small specimens amongst dredgings from Queen's Ground and Asia Shoal. Recorded in previous list as *N. irrorata*.

SALCOMBE. Common in muddy gravel under the Marine Hotel. Also found on the east side of the harbour, and one specimen in Kingsbridge Estuary south of Halwell Point (Journ. M.B.A., vol. 6, 1900, p. 191, as N. irrorata).

EXMOUTH. One specimen from Orcombe rocks at the mouth of the estuary (Journ. M.B.A., vol. 6, 1902, p. 319, as N. irrorata).

TORQUAY. Occasionally under stones at Petit Tor Bay and Babbacombe Beach ; amongst roots of Zostera at Corbyn's Head (*Elwes*, Journ. M.B.A., vol. 8, 1909, p. 352).

NEREIS (PLATYNEREIS) DUMERILII Audouin and Edwards : *McIntosh*, Mon. Brit. Ann. II. 2, 1910, p. 302.

PLYMOUTH. Small specimens are common on all the dredging grounds of the Sound, the largest specimens coming from Queen's Ground. In dredgings from Yealm River. Occasional specimens are obtained from the shores of the Sound and from Millbay Docks.

TORQUAY. Small individuals very common amongst algæ from rock pools (*Elwes*, Journ. M.B.A., vol. 8, 1909, p. 351).

NEREIS (HEDISTE) DIVERSICOLOR O. F. Müller : *McIntosh*, Mon. Brit. Ann. II. 2, 1910, p. 312.

PLYMOUTH. Common in the mud flats of the Tamar and Plym estuaries, seldom in the Sound ; found only where the density of the water is low.

SALCOMBE. Numerous only in a small gully traversed by a stream of fresh water which runs into Southpool Lake. Occasional specimens found in other parts of the harbour (Journ. M.B.A., vol. 6, 1900, p. 193).

EXMOUTH. Very common in the upper parts of the estuary where the density of the water is low (Journ. M.B.A., vol. 6, 1902, p. 319).

NEREIS (EUNEREIS) LONGISSIMA Johnston : *McIntosh*, Mon. Brit. Ann. II. 2, 1910, p. 325.

PLYMOUTH. Occasional specimens in fine sand between tide-marks on Drake's Island and Mount Edgcumbe shore. Recorded by Cunningham from a mud-bank in the Cattewater near Oreston.

The Heteronereis stage is sometimes very numerous swimming in the Cattewater, the largest numbers being reported from near

Laira Bridge. It has also been reported as numerous in the Hamoaze. It generally swims at night.

SALCOMBE. In fine muddy sand, especially abundant south of Garston Point and on the south side of the bay immediately below Halwell Point (Journ. M.B.A., vol. 6, 1900, p. 192, where further details as to its habitat and habits are given).

EXMOUTH. One specimen on Bullhill Bank and one from the mud north of Salthouse Lake (Journ. M.B.A., vol. 6, 1902, p. 319).

NEREIS (NEREILEPAS) FUCATA Savigny : *McIntosh*, Mon. Brit. Ann. II. 2, 1910, p. 336.

PLYMOUTH. In shells of *Buccinum undatum* inhabited by *Eupagurus Bernhardus :* Mewstone Grounds, Rame-Eddystone, Looe-Eddystone and Eddystone Grounds.

Found by Crawshay at two positions S.S.W. of Eddystone in 42–47 fms., associated with *Anapagurus lævis* (Journ. M.B.A., vol. 9, 1912, p. 342).

S. Pace records a specimen from Yealm River.

Breeding. May (W.G.).

SALCOMBE. From a Hermit Crab on Millbay Sands (Journ. M.B.A., vol. 6, 1900, p. 193).

EXMOUTH. In a shell inhabited by *E. Bernhardus* at Orcombe Rocks (Journ. M.B.A., vol. 6, 1902, p. 318).

TORQUAY. In whelk shells thrown up on shore (*Elwes*, Journ. M.B.A., vol. 8, 1909, p. 351).

NEPHTHYDIDÆ.

NEPHTHYS CÆCA (O. F. Müller) : *McIntosh*, Mon. Brit. Ann. II. 1, 1908, p. 8.

PLYMOUTH. Large specimens on sandy shores, especially Drake's Island, Rum Bay and Yealm Sand-bank (T.V.H., R.A.T., E.J.A.).

SALCOMBE. Only on the banks near the mouth of the harbour, being most numerous on the eastern side (Journ. M.B.A., vol. 6, 1900, p. 193).

EXMOUTH. Several large specimens from Bullhill Bank (Journ. M.B.A., vol. 6, 1902, p. 319).

NEPHTHYS HOMBERGI Lamarck : *McIntosh*, Mon. Brit. Ann. II. 1, 1908, p. 17.

PLYMOUTH. Shore between tide-marks especially in sand, Drake's Island, Rum Bay, Jennycliff Bay, Bovisand, Wembury Bay, Whitsand Bay, Yealm River (R.A.T., E.J.A.) : dredged on Mewstone *Amphioxus* Ground (R.A.T.) and Eddystone Grounds (T.V.H.).

SALCOMBE. One of the commonest shore Polychætes in Salcombe Estuary. On all grounds except finest mud (Journ. M.B.A., vol. 6, 1900, p. 193).

EXMOUTH. Common in sand and muddy sand all over the estuary (Journ. M.B.A., vol. 6, 1902, p. 319).

TORQUAY. Common in sand at Tor Abbey Sands and Livermead. In dirty, muddy sand in the inner harbour of Torquay (*Elwes*, Journ. M.B.A., vol. 8, 1909, p. 350).

NEPHTHYS CIRROSA Ehlers: *McIntosh*, Mon. Brit. Ann. II. 1, 1908, p. 36.

PLYMOUTH. In sand between tide-marks, Drake's Island and Yealm Estuary.

EXMOUTH. In considerable numbers on grounds where the soil was fine clean sand, but did not occur in any other localities (Journ. M.B.A., vol. 6, 1902, p. 319).

TORQUAY. In clean sand in company with *N. Hombergi*, but not quite so numerous (*Elwes*, Journ. M.B.A., vol. 8, 1909, p. 350).

EUNICIDÆ.

STAUROCEPHALUS RUBROVITTATUS Grube: *McIntosh*, Mon. Brit. Ann. II. 2, 1910, p. 353.

PLYMOUTH. Frequent in dredgings from Millbay Channel, Queen's Ground, Asia Shoal, Duke Rock. Also taken 2 miles off Yealm Head.

TORQUAY. One specimen at an unusually low spring tide at Corbyn's Head (*Elwes*, Journ. M.B.A., vol. 9, 1910, p. 61).

STAUROCEPHALUS CILIATUS (Keferstein): Ehlers, Borstenwürmer, 1868, p. 424.

PLYMOUTH. Recorded once from Queen's Ground dredging. No further specimens have been obtained since the one entered in the former list. The specimen has four eyes, an anterior pair of large eyes and a posterior pair of small ones, as described by Ehlers and Keferstein. In this respect it differs from the *S. ciliatus* of McIntosh (Mon. Brit. Ann. II. 2, 1910, p. 359), which is described as having two eyes, black, large and distinct.

STAUROCEPHALUS PALLIDUS Langerhans: Zeit. wiss. Zool. XXXIII. 1879, p. 300. *McIntosh*, Mon. Brit. Ann. II. 2, 1910, p. 362 and p. 363.

PLYMOUTH. Recorded once from Asia Shoal dredging. In the former list it was stated that the species " resembles *S. ciliatus* Kef., excepting for absence of eyes." This should have read " excepting for the absence of the posterior pair of eyes." The specimen, as McIntosh (*l.c.* p. 362) who examined it points out, has two very distinct eyes situated near the base of the tentacles. As regards the eyes, therefore, the specimen does not differ from the *S. ciliatus* with two eyes described by McIntosh; it does differ, however, from the *S. ciliatus* described by Keferstein and Ehlers, which has four eyes. It agrees with *S. pallidus* Langerhans, which has two eyes. The correct synonymy of the two species, if indeed they are really distinct, can only be settled by further research.

OPHRYOTROCHA PUERILIS Claparède and Mecznikow: *McIntosh*, Mon. Brit. Ann. II. 2, 1910, p. 364.

PLYMOUTH. Frequently met with in dredgings from the Sound, especially from Asia Shoal. Sometimes very numerous in dredgings from the Cattewater. Often common in the Laboratory tanks.

Breeding: August (W.G.). Spawned in tanks, May (A.J.S.).

TORQUAY. Frequent on the sides of glass vessels containing roots and pieces of rock. A small aquarium was found to be swarming with this species (Elwes, Journ. M.B.A., vol. 9, 1910, p. 61).

LUMBRICONEREIS FRAGILIS O. F. Müller: *McIntosh*, Mon. Brit. Ann. II. 2, 1900, p. 372.

PLYMOUTH. Two specimens (both incomplete) from a depth of 47–49 fms. S.S.W. of the Eddystone are provisionally referred to this species by Crawshay (Journ. M.B.A., vol. 9, 1912, p. 342).

Southern (Proceed. R. Irish Acad. XXXI. 47, 1914, p. 85) thinks that *L. fragilis* O. F. Müller and *L. impatiens* Claparède may prove to be identical.

LUMBRICONEREIS LATREILLI Audouin and Edwards: *McIntosh*, Mon. Brit. Ann. II. 2, 1910, p. 376.

PLYMOUTH. Shores of the Sound between tide-marks (Drake's Island, Mount Edgcumbe, Rum Bay); amongst dredgings from Millbay Channel, Asia Shoal, Queen's Ground, Yealm River and Eddystone Grounds.

SALCOMBE. A number of specimens on the west side of the harbour under the Marine Hotel. A few were found in other parts of the estuary (Journ. M.B.A., vol. 6, 1900, p. 191).

TORQUAY. Three or four in rather coarse gravel on Babbacombe Beach (Journ. M.B.A., vol. 9, 1910, p. 61).

LUMBRICONEREIS IMPATIENS Claparède: *McIntosh*, Mon. Brit. Ann. II. 2, 1910, p. 379.

PLYMOUTH. Occurs in dredge and trawl material from the Rame-Eddystone, Looe-Eddystone and Mewstone Grounds, especially from gravel; very abundant on Queen's Ground in the spring of 1903.

ARABELLA (MACLOVIA) IRICOLOR (Montagu): *McIntosh*, Mon. Brit. Ann. II. 2, 1910, p. 395.

PLYMOUTH. Occasional specimens at low-water mark on the shores of the Sound and Wembury Bay.

SALCOMBE. In muddy gravel on the west side of the Salstone and in sand near the mouth of the harbour. Interesting as being the locality in which Montagu chiefly collected (Journ. M.B.A., vol. 6, 1900, p. 191).

ONUPHIS BRITANNICA McIntosh : Mon. Brit. Ann. II. 2, 1910, p. 404.

PLYMOUTH. On coarse shell-gravel grounds, in depths from 20 to 30 fms. off the Mewstone, off Stoke Point, South of Rame Head and off the Eddystone (E.J.A., R.A.T.).

Recorded in the former list as *O. conchilega* M. Sars.

Crawshay found it at several positions S.S.W. of the Eddystone in depths of 42–44 fms. (Journ. M.B.A., vol. 9, 1912, p. 342, as *O. conchilega*).

HYALINŒCIA SICULA Quatrefages : *McIntosh*, Mon. Brit. Ann. II. 2, p. 417 (=*H. bilineata* Baird).

PLYMOUTH. Dredged from shell-gravel ground off Yealm Head.

HYALINŒCIA TUBICOLA (O. F. Müller) : *McIntosh*, Mon. Brit. Ann. II. 2, 1910, p. 419.

PLYMOUTH. Common on muddy-gravel grounds from 20 to 30 fms. : off the Mewstone, Rame-Eddystone and Eddystone Grounds (E.J.A., R.A.T.).

Common and widely distributed on the area S.S.W. of the Eddystone at depths of 40–52 fms. (*Crawshay*, Journ. M.B.A., vol. 9, 1912, p. 342).

EUNICE HARASSI Audouin and Edwards : *Fauvel*, Résult. Camp. Sci. Monaco, Fas. XLVI. Annél. Polych., 1914, p. 134. *McIntosh*, Mon. Brit. Ann. II. 2, 1910, p. 425 as *E. fasciata* Risso.

PLYMOUTH. On the shore, Drake's Island, Rum Bay, Breakwater (R.A.T., E.J.A.) : Wembury Bay (E.J.A.). In dredgings from Duke Rock (W.G., T.V.H.) : Queen's Ground, Asia Shoal, Millbay Channel (R.A.T., E.J.A.) : south of Breakwater Fort (W.G.) : Rame-Eddystone Grounds.

Crawshay obtained three specimens S.S.W. of the Eddystone in 40–42 fms. (Journ. M.B.A., vol. 9, 1912, p. 342).

The synonymy of this species has recently been revised by Fauvel. He gives reasons for considering that the *E. Harassii* described by Claparède and Ehlers and probably also *E. fasciata* Risso are not the present species but *E. torquata* Quatrefages.

EUNICE VITTATA Delle Chiaje : *McIntosh*, Mon. Brit. Ann. II. 2, 1910, p. 431.

PLYMOUTH. McIntosh (*loc. cit.*) gives Plymouth as a locality on the authority of C. S. Bate, and Polperro on that of W. Baird. One specimen was dredged by Crawshay 16 miles S. 25° W. of the Eddystone in 42 fms. (Journ. M.B.A., vol. 9, 1912, p. 342).

MARPHYSA SANGUINEA (Montagu) : *McIntosh*, Mon. Brit. Ann. II. 2, 1910, p. 442.

PLYMOUTH. Frequent on the shore in crevices of rock, especially on the bridge between Drake's Island and Mount Edgcumbe; also Rum Bay, Wembury Bay and Yealm Estuary (W.G., T.V.H., R.A.T., E.J.A.).

SALCOMBE. A few specimens were found in different parts of the harbour. Interesting as being the locality in which Montagu chiefly collected (Journ. M.B.A., vol. 6, 1900, p. 191).

EXMOUTH. One specimen from Orcombe Rocks (Journ. M.B.A., vol. 6, 1902, p. 318).

MARPHYSA BELLI (Audouin and Edwards): *McIntosh*, Mon. Brit. Ann. II. 2, 1910, p. 448.

PLYMOUTH. On the shore between tide-marks, N. side of Drake's Island and Rum Bay: very common in the *Zostera* beds at the mouth of the Yealm River.

SALCOMBE. Specimens were obtained on the Salstone and near the mouth of Salcombe Harbour (under Marine Hotel) (Journ. M.B.A., vol. 6, 1900, p. 191).

NEMATONEREIS UNICORNIS (Grube): *McIntosh*, Mon. Brit. Ann. II. 2, 1910, p. 453.

PLYMOUTH. Between tide-marks, N. side of Drake's Island, Mount Edgcumbe and Yealm Sand-bank. Amongst dredgings from Queen's Ground, Asia Shoal and Millbay Channel.

TORQUAY. Fairly common in the limestone rocks at Babbacombe (*Elwes*, Journ. M.B.A., vol. 9, 1910, p. 61).

LYSIDICE PUNCTATA (Risso): *McIntosh*, Mon. Brit. Ann. II. 2, 1910, p. 456.

PLYMOUTH. Frequent in Plymouth Sound, on the shore between tide-marks (Rum Bay, Drake's Island), and in dredgings (Asia Shoal, Millbay Channel, Queen's Ground). On the shore at Wembury Bay and Reny Rocks. Dredged in Yealm River. Recorded in former list as *L. ninetta* Aud. and Edw.

TORQUAY. Small specimens 30 to 50 mm. long, extremely common amongst Laminarian roots and limestone rocks (*Elwes*, Journ. M.B.A., vol. 9, 1910, p. 60 as *L. ninetta*).

SPHÆRODORIDÆ.

EPHESIA GRACILIS Rathke: *McIntosh*, Mon. Brit. Ann. III. 1, 1915, p. 47.

PLYMOUTH. Frequently met with from all dredging grounds in the Sound and outside to the Eddystone Grounds. Most common Millbay Channel and Asia Shoal. Also found on the shore between tide-marks, Drake's Island and Mount Edgcumbe.

Single specimens dredged on a number of grounds S.S.W. of the Eddystone in 42–47 fms. by Crawshay (Journ. M.B.A., vol. 9, 1912, p. 343).

TORQUAY. Two or three from Meadfoot Beach (*Elwes*, Journ. M.B.A., vol. 9, 1910, p. 61).

EPHESIA PERIPATUS Claparède : *McIntosh*, Mon. Brit. Ann. III. 1, 1915, p. 50.

TORQUAY. Two specimens from Corbyn's Head (*Elwes*, Journ. M.B.A., vol. 9, 1910, p. 61).

SPHÆRODORUM MINUTUM (Webster and Benedict) : *Southern*, Proceed. Roy. Irish Acad. XXXI. 47, 1914, p. 90.

PLYMOUTH. Amongst Laminaria roots from Rum Bay ; a number of specimens. From material trawled in the Cattewater.

GLYCERIDÆ.

GONIADA MACULATA Oersted : *McIntosh*, Mon. Brit. Ann. II. 2, 1910, p. 462.

PLYMOUTH. Occasional specimens from the shores of the Sound. Dredged in fine mud in the Sound.

SALCOMBE. A few specimens from the shore near the mouth of the harbour on both sides. (Journ. M.B.A., vol. 6, 1900, p. 194).

GLYCERA LAPIDUM Quatrefages : *McIntosh*, Mon. Brit. Ann. II. 2, 1910, p. 477.

PLYMOUTH. Between tide-marks Wembury Bay and Drake's Island (in shell gravel) : dredged in shell gravel off the Mewstone and near Queen's Ground, not uncommon.

SALCOMBE. The species recorded as *Glycera capitata* dredged between the Salstone and Snape's Point is probably this form (Journ. M.B.A., vol. 6, 1900, p. 194).

TORQUAY. One specimen in the inner harbour of Torquay and one on the Babbacombe Beach (*Elwes*, Journ. M.B.A., vol. 9, 1910, p. 60).

GLYCERA SIPHONOSTOMA Delle Chiaje : *McIntosh*, Mon. Brit. Ann. II. 2, p. 482 (=*G. gigantea* Quatrefages).

PLYMOUTH. Between tide-marks, Drake's Island (W.G., R.A.T.). Mewstone *Amphioxus* ground.

Recorded in the former list as *Glycera gigantea* Quatrefages.

GLYCERA ALBA Blainville : *McIntosh*, Mon. Brit. Ann. II. 2, p. 486 (=*G. convoluta* Keferstein).

PLYMOUTH. The most common Glycera of the inshore waters. Between tide-marks Drake's Island, Jennycliff Bay, Yealm Estuary. In dredgings from Millbay Channel, Rame-Eddystone and Eddystone Grounds.

Recorded in the former list is *G. convoluta* Keferstein.

SALCOMBE. Nowhere abundant. Two or three specimens from the shore in Salcombe Harbour (Journ. M.B.A., vol. 6, 1900, p. 194, as *G. convoluta*).

EXMOUTH. Found occasionally on Bullhill Bank and on the gravel between Powderham and Starcross (Journ. M.B.A., vol. 6, 1902, p. 319, as *G. convoluta*).

TORQUAY. Fairly numerous in Tor Abbey Sands and at Livermead (*Elwes*, Journ. M.B.A., vol. 9, 1910, p. 60, as *G. convoluta*).

GLYCERA GOËSI Malmgren: *McIntosh*, Mon. Brit. Ann. II. 2, 1910, p. 491 (=*G. Mesnili* de St. Joseph).

PLYMOUTH. On the shore at Drake's Island, and in other parts of the Sound. Not uncommon. Dredged off Stoke Point and near the Eddystone.

This is the *G. Mesnili* of de St. Joseph. McIntosh considers it the same as *G. Goësi* of Malmgren, but this seems to me open to doubt, if Malmgren's figure of the gill is correct. Fauvel (Résult. Camp. Sci. Monaco, 1914, p. 203) adopts the synonym *G. Rouxii* Audouin and Edwards.

ARICIIDÆ.

ARICIA CUVIERI Audouin and Edwards: *McIntosh*, Mon. Brit. Ann. II. 2, 1910, p. 497.

PLYMOUTH. Occasional specimens dredged off the Mewstone.

ARICIA LATREILLI Audouin and Edwards: *McIntosh*, Mon. Brit. Ann. II. 2, 1910, p. 502.

EXMOUTH. Large specimens were moderately plentiful in the hard sand on the south of the Pole Sands (Journ. M.B.A., vol. 6, 1902, p. 321).

TORQUAY. In the sand at Tor Abbey Sands (*Elwes*, Journ. M.B.A., vol. 9, 1910, p. 61).

SCOLOPLOS ARMIGER (O. F. Müller): *McIntosh*, Mon. Brit. Ann. II. 2, 1910, p. 510.

PLYMOUTH. In dirty sand and between layers of shale at Rat Island (Hamoaze) (W.G.). In sand at Drake's Island, Rum Bay and the Yealm Estuary.

SALCOMBE. A few specimens were found in the *Zostera* banks near the mouth of the harbour, on both the east and west sides (Journ. M.B.A., vol. 6, 1900, p. 194).

EXMOUTH. Not uncommon in sand on all the banks in the upper part of the estuary (Journ. M.B.A., vol. 6, 1902, p. 321).

SPIONIDÆ.

NERINE FOLIOSA (Audouin and Edwards): *McIntosh*, Mon. Brit. Ann. III. 1, 1915, p. 142.

PLYMOUTH. Wembury Bay (T.V.H.). In sand between tide-marks on the east side of Drake's Island, on the eastern side of the Sound, on Kingsand Beach (Cawsand Bay), Yealm Sand-bank, occasional specimens at each locality.

Recorded in the former list as *N. coniocephala* Johnston.

SALCOMBE. One specimen from the shore on the east side of the harbour (Journ. M.B.A., vol. 6, 1900, p. 194, as *N. coniocephala*).

TEIGNMOUTH. In sand in the estuary.

EXMOUTH. Several specimens were obtained in the sand west of Salthouse Lake and in the hard clayey mud to the north of it (Journ. M.B.A., vol. 6, 1902, p. 320, as *N. coniocephala*).

NERINE CIRRATULUS (Delle Chiaje): *McIntosh*, Mon. Brit. Ann. III. 1, 1915, p. 148.

PLYMOUTH. In fine gravel between tide-marks on the eastern side of Plymouth Sound, occasional specimens only.

SALCOMBE. One specimen was obtained on the shore on the west side of the harbour, under the Marine Hotel (Journ. M.B.A., vol. 6, 1910, p. 194).

EXMOUTH. Bullhill Bank and Cocklesands (Journ. M.B.A., vol. 6, 1902, p. 321).

TORQUAY. Tor Abbey Sands; not numerous (*Elwes*, Journ. M.B.A., vol. 9, 1910, p. 62).

SCOLECOLEPIS VULGARIS (Johnston): *McIntosh*, Mon. Brit. Ann. III. 1, 1915, p. 156 (=*S. Girardi* Quatrefages).

PLYMOUTH. Occasional specimens only from Rum Bay.

Recorded in the former list as *Scolelepis Giardi* (de Quatrefages), a misprint for *S. Girardi*.

TORQUAY. At the west end of Tor Abbey Sands; rare (*Elwes*, Journ. M.B.A., vol. 9, 1910, p. 62).

There is considerable difficulty as to the proper names to give to this and the following species. I have in this list followed *McIntosh's* monograph, though I feel some doubt as to whether the synonymy adopted by him is correct. Mesnil (Bull. Sci. France et Belg. XXIX. 1896) and de St. Joseph (Ann. Sci. Nat. Zool. XVII. 1894, p. 77) were both unable to satisfy themselves of the identity of *S. vulgaris* (Johnston) with *S. Girardi* (Quatrefages). Johnston no doubt had before him the common British species, inhabiting "the shore between tide-marks, ascending tidal rivers as far as the water is made brackish." Speaking of *N. coniocephala* he says, "This species inhabits our shores at low-water mark, and is seldom found with the preceding (i.e. *N. vulgaris*), *which loves a station higher up*" (Cat. Brit. Mus. 1865, pp. 200 and 201). In the south-west of England this account of the habitat applies not to *S. Girardi*, but to *S. fuliginosa*, which is the common shore and estuarine form, occurring in very large numbers, whereas isolated specimens of *S. Girardi* are only very occasionally found. On the west coast of Ireland, Southern (Proceed. R. Irish Acad. XXXI. 47, 1914, p. 96) found *S. vulgaris* of McIntosh (=*S. Girardi* of Mesnil) generally living in sand, rarely in Laminaria roots, and it was never abundant. *S. fuliginosa* was common locally in Blacksod Bay, but not widely distributed. Mesnil (*loc. cit.* p. 146) thinks it probable that the *S. vulgaris* of Cunningham and Ramage, which was abundant in the Firth of Forth, is *S. fuliginosa*, and that *S. fuliginosa* is the common species at Heligoland.

SCOLECOLEPIS FULIGINOSA (Claparède): *McIntosh*, Mon. Brit. Ann. III. 1, 1915, p. 160.

PLYMOUTH. Very numerous in places in black mud at Rum Bay, Wembury Bay and Yealm Estuary.

Recorded in former list as "*Scolelepis vulgaris* Johnston (probably the same as *S. fuliginosa* Claparède, *var. macrochæta major* of Mesnil)."

SALCOMBE. One small one dredged between Salstone and Snape's Point (Journ. M.B.A., vol. 6, 1900, p. 194, as *Nerine vulgaris* Johnston).

TORQUAY. Very numerous at west end of Tor Abbey Sands and at Livermead. In December numbers were found coiled up together under stones (*Elwes*, Journ. M.B.A., vol. 9, 1910, p. 62)

SCOLECOLEPIS (LAONICE) CIRRATA (Sars): *McIntosh*, Mon. Brit. Ann. III. 1, 1915, p. 164.

PLYMOUTH. McIntosh (*loc. cit.*) gives Plymouth as a locality on the authority of Spence Bate and Brooking Rowe. I have not seen any specimens from this neighbourhood.

SPIOPHANES BOMBYX (Claparède): *McIntosh*, Mon. Brit. Ann. III. 1, 1915, p. 182.

TORQUAY. A few specimens at the east end of Tor Abbey Sands (*Elwes*, Journ. M.B.A., vol. 9, 1910, p. 62).

AONIDES OXYCEPHALA (Sars): *McIntosh*, Mon. Brit. Ann. III. 1, 1915, p. 186.

PLYMOUTH. In the *Zostera* bed at low-water mark, eastern shore of Yealm mouth, very numerous. Yealm Sand-bank, occasional specimens. Rum Bay and Wembury Bay in crevices of shale. In sand at Wembury Bay.

TORQUAY. Numerous in rather foul mud under stones at Livermead (*Elwes*, Journ. M.B.A., vol. 9, 1910, p. 62).

TEIGNMOUTH. From sand in the estuary.

SPIO FILICORNIS Fabricius : *McIntosh*, Mon. Brit. Ann. III. 1, 1915, p. 172.

PLYMOUTH. In fine, clean sand at Wembury Bay, at low tide.

The head of the living worm was conical, the point being used in attempts to burrow. The point could be bent downwards into the shape of a hook.

PYGOSPIO ELEGANS Claparède : *McIntosh*, Mon. Brit. Ann. III. 1, 1915, p. 189.

PLYMOUTH. Forming tubes in very fine sand near the mouth of the Yealm River.

Breeding : March.

EXMOUTH. In the clean hard sand of the estuary. Not found on the more exposed Pole Sands (Journ. M.B.A., vol. 6, 1902, p. 320).

TEIGNMOUTH. Abundant in sand below Shaldon Bridge.

PYGOSPIO SETICORNIS (Oersted) : *Mesnil*, Bull. Sci. France et Belg. XXX. 1897, p. 85 ; *Cunningham and Ramage*, Trans. Roy. Soc. Edinburgh, XXXIII. 1888, p. 640.

SALCOMBE. Abundant on the shore under the Marine Hotel, forming long, slender tubes or galleries of mucus covered with sand grains (Journ. M.B.A., vol. 6, 1900, p. 194).

EXMOUTH. In clean hard sand in the estuary (Journ. M.B.A., vol. 6, 1902, p. 320).

The gills on the second setigerous segment are still very conspicuous and unmistakable in some of the preserved specimens which have recently been re-examined. Mesnil (*loc. cit.*) thinks that this form is not the *Spio seticornis* of Fabricius. Excepting for the presence of the gills on the second setigerous segment the species very closely resembles *Pygospio elegans* of Claparède.

POLYDORA CILIATA (Johnston) : *McIntosh*, Mon. Brit. Ann. III. 1, 1915, p. 198.

PLYMOUTH. Boring in limestone of the Breakwater and in limestone dredged in Millbay Channel. Boring in shells of Purpura and Littorina from Yealm Sand-bank. Frequently found in oyster shells.

TORQUAY. Very numerous in the small pools in the limestone boulders on the shore (*Elwes*, Journ. M.B.A., vol. 9, 1910, p. 62).

POLYDORA FLAVA Claparède : *McIntosh*, Mon. Brit. Ann. III. 1, 1915, p. 205.

PLYMOUTH. At Rum Bay and Rat Island (Hamoaze), common in crevices of shale (W.G.). In holes in limestone below the Laboratory and in dredgings from Yealm River.

Breeding : February (W.G.).

TORQUAY. Numerous on rocks and in pools (*Elwes*, Journ. M.B.A., vol. 9, 1910, p. 62).

POLYDORA CAECA (Oersted) : *Mesnil*, Bull. Sci. France et Belg. XXIX. 1896, p. 191.

PLYMOUTH. Eddystone Grounds (T.V.H.). On the shore at Rum Bay in crevices of shale.

POLYDORA HOPLURA Claparède: *McIntosh*, Mon. Brit. Ann. III. 1, 1915, p. 212.

PLYMOUTH. Boring in limestone of the Plymouth Breakwater.

MAGELONA PAPILLICORNIS Fr. Müller: *McIntosh*, Mon. Brit. Ann. III. 1, 1915, p. 223.

PLYMOUTH. In fine sand near low-water mark at Jennycliff Bay, under Batten Castle, on the south shore of Yealm Estuary, and in Wembury Bay.

Larvæ in townets in July and August (E.J.A.); in September (E.J.B.).

TORQUAY. One example at a very low spring tide on Tor Abbey Sands (*Elwes*, Journ. M.B.A., vol. 9, 1910, p. 62).

DISOMIDÆ.

POECILOCHÆTUS SERPENS Allen: Quart. Journ. Micr. Sci. vol. XLVIII. 1904, p. 79.

PLYMOUTH. In sand at low tide south of Batten Castle; larvæ not uncommon in the plankton during the summer months.

Adults have since been found by Southern in sand on the shore of Lough Swilly (Proceed. Roy. Irish Acad. XXXI. 47, 1914, p. 105).

CHÆTOPTERIDÆ.

CHÆTOPTERUS VARIOPEDATUS (Renier): *McIntosh*, Mon. Brit. Ann. III. 1, 1915, p. 120.

PLYMOUTH. Common in muddy gravel on the Eddystone Grounds, Rame-Eddystone and Looe-Eddystone Grounds (E.J.A.); occasional specimens Duke Rock (T.V.H.); Asia Shoal (R.A.T.), Millbay Channel (R.A.T., E.J.A.) and Mewstone *Echinoderm* Ground (R.A.T.): Stoke Point Grounds (S.P.). A few specimens at a number of positions S.S.W. of the Eddystone in depths of 40–51 fms. were taken by Crawshay (Journ. M.B.A., vol. 9, 1912, p. 343).

Larvæ in townettings July to October (W.G.).

Breeding. Ripe eggs and sperm in July (A.J.S., E.J.A.).

SALCOMBE. Found on the shore at extreme low water on the west side of the Salstone and on the *zostera* bank near the mouth of the harbour on the western side. (Journ. M.B.A., vol. 6, 1900, p. 195).

PHYLLOCHÆTOPTERUS ANGLICA Potts: Proceed. Zool. Soc. London, 1914, p. 984.

PLYMOUTH. From material brought in by trawlers from some locality to the south of the Eddystone (*Potts, loc. cit.*).

AMMOCHARIDÆ.

OWENIA FUSIFORMIS Delle Chiaje: *McIntosh,* Mon. Brit. Ann. III. 1, 1915, p. 356.

PLYMOUTH. In fine sand near low-water mark at Jennycliff Bay and under Batten Castle.

SALCOMBE. In clean fine sand at Millbay (Journ. M.B.A., vol. 6, 1900, p. 195).

TEIGNMOUTH. In sand below Shaldon Bridge on the east side.

TORQUAY. Very numerous in Tor Abbey Sands (*Elwes,* Journ. M.B.A., vol. 9, 1910, p. 62).

CIRRATULIDÆ.

CIRRATULUS (AUDOUINIA) TENTACULATUS (Montagu): *McIntosh,* Mon. Brit. Ann. III. 1, 1915, p. 242.

PLYMOUTH. Common in gravel and sand just below high-water mark on all shores both inside and outside the Sound, excepting on open sandy beaches. Occasional small specimens dredged in shallow water amongst the roots of weeds.

SALCOMBE. Very common all over the estuary above half-tide mark, wherever the soil contains much mud mixed either with gravel or sand (Journ. M.B.A., vol. 6, 1900, p. 194).

EXMOUTH. One specimen only was obtained from Orcombe Rocks quite at the mouth of the estuary. The entire absence of the species from the estuary itself is noteworthy (Journ. M.B.A., vol. 6, 1902, p. 320).

TORQUAY. Numerous at Meadfoot, Hope's Nose and Tor Abbey Sands in rather foul mud (*Elwes,* Journ. M.B.A., vol. 9, 1910, p. 63).

CIRRATULUS CIRRATUS (O. F. Müller): *McIntosh,* Mon. Brit. Ann. III. 1, 1915, p. 249.

PLYMOUTH. McIntosh (*loc. cit.* p. 250) gives Plymouth as a locality on the authority of Spence Bate and Brooking Rowe. I have obtained a number of specimens from crevices in the shale at Rum Bay, and from the shore below the Laboratory. Small specimens have been obtained from dredgings in the Cattewater and from scrapings of the piles in Millbay Dock.

CIRRATULUS NORVEGICUS (Quatrefages): *Southern,* Proceed. Roy. Irish Acad. XXXI. 47, 1914, p. 107.

PLYMOUTH. A specimen was obtained from crevices in the shale at Rum Bay. Mr. Southern has kindly confirmed the identification.

DODECACERIA CONCHARUM, Oersted: *McIntosh,* Mon. Brit. Ann. III. 1, 1915, p. 255.

PLYMOUTH. Boring in limestone on Plymouth Breakwater, abundant ; also in limestone below the Laboratory and from Millbay Channel.

TORQUAY. Very numerous in the limestone boulders at Babbacombe (*Elwes*, Journ. M.B.A., vol. 9, 1910, p. 63).

HETEROCIRRUS VIRIDIS (Langerhans) : *McIntosh*, Mon. Brit. Ann. III. 1, 1915, p. 261.

TORQUAY. Found occasionally in small pools in limestone rocks at Babbacombe (*Elwes*, Journ. M.B.A., vol. 9, 1910, p. 63).

HETEROCIRRUS CAPUT-ESOCIS de St. Joseph : *McIntosh*, Mon. Brit. Ann. III. 1, 1915, p. 263.

TORQUAY. Two or three found in small pools in limestone rocks at Babbacombe (*Elwes*, Journ. M.B.A., vol. 9, 1910, p. 63).

TEREBELLIDÆ.

AMPHITRITE GRACILIS GRUBE : *de St. Joseph*, Ann. Sci. Nat. Zool. XVII. 1894, p. 198.

PLYMOUTH. Common in sand between tide-marks and between layers of shale in Rum Bay and at Mount Edgcumbe, Yealm Sandbank and Wembury Bay. Dredged at Millbay Channel and Eddystone Grounds.

AMPHITRITE JOHNSTONI Malmgren : *de St. Joseph*, Ann. Sci. Nat. Zool. V. 1898, p. 421.

PLYMOUTH. In sand and gravel near low-water mark along the southern shore of the Yealm River ; most common on the east shore where the stream divides (R.A.T., E.J.A.). Occasional specimens from Rum Bay.

SALCOMBE. Very abundant on the Salstone, especially on the north-east and south-east sides. Occasionally met with on the shore in all parts of the Kingsbridge Estuary and Salcombe Harbour, being abundant on the western shore near the mouth of the harbour (under Marine Hotel) (Journ. M.B.A., vol. 6, 1900, p. 195).

AMPHITRITE EDWARDSI Quatrefages : *de St. Joseph*, Ann. Sci. Nat. Zool. XVII. 1894, p. 186.

SALCOMBE. In the *Zostera* banks near the mouth of Salcombe Harbour, being especially abundant on the western side (under Marine Hotel). In the latter locality *A. Johnstoni* is also found, but is more abundant at a somewhat lower tidal level. *A. Edwardsi* was never found in the Kingsbridge Estuary, where *A. Johnstoni* was common.

The burrows of *A. Edwardsi* were generally occupied by the Polynoid *Lepidasthenia argus* (Journ. M.B.A., vol. 6, 1900, p. 196).

TEREBELLA (LEPRÆA) LAPIDARIA Linn. : *de St. Joseph*, Ann. Sci. Nat. Zool. XVII. 1894, p. 202.

PLYMOUTH. Common in crevices of shale at Rum Bay (R.A.T., E.J.A.).

Polymnia nebulosa (Montagu): *de St. Joseph*, Ann. Sci. Nat. Zool. XVII. 1894, p. 219.

Plymouth. Very common between tide-marks at Mount Edgcumbe (R.A.T., E.J.A.): occasional specimens on the shore at Rum Bay and in dredgings from Millbay Channel, Asia Shoal, Queen's Ground and Yealm River (R.A.T., E.J.A.): Eddystone Grounds (T.V.H.).

Dredged by Crawshay at a number of stations S.S.W. of the Eddystone in 40–50 fms. (Journ. M.B.A., vol. 9, 1912, p. 343).

Salcombe. Dredged in the channel west of the Salstone (Journ. M.B.A., vol. 6, 1900, p. 197).

Exmouth. A few specimens from Exmouth Dock and from dredging material from the sponge ground below the pier (Journ. M.B.A., vol. 6, 1902, p. 321).

Torquay. Occasional specimens at Corbyn's Head and in rocks between Oddicombe and Babbacombe beaches (*Elwes*, Journ. M.B.A., vol. 9, 1910, p. 63).

Polymnia nesidensis (Delle Chiaje): *de St. Joseph*, Ann. Sci. Nat. Zool. XVII. 1894, p. 225.

Plymouth. Between tide-marks at Rum Bay, Mount Edgcumbe, Wembury Bay: dredged at Asia Shoal, Yealm River and Cawsand Bay.

One specimen dredged S.S.W. of the Eddystone by Crawshay at a depth of 49 fms. (Journ. M.B.A., vol. 9, 1912, p. 343).

Torquay. Very common in Laminaria roots, etc. (*Elwes*, Journ. M.B.A., vol. 9, 1910, p. 63).

Lanice conchilega (Pallas): *de St. Joseph*, Ann. Sci. Nat. Zool. XVII. 1894, p. 211.

Plymouth. Common on sandy shores inside and outside the Sound; occasionally dredged on Queen's Ground; Eddystone Grounds (T.V.H., R.A.T., E.J.A.).

Empty tubes were dredged by Crawshay S.S.W. of the Eddystone at depths from 42 to 49 fms. (Journ. M.B.A., vol. 9, 1912, p. 343).

Salcombe. Extremely abundant in patches of clean sand near the mouth of the harbour on both sides, and in sheltered parts of sandy bays outside the harbour. Found only occasionally in the upper parts of the estuary (Journ. M.B.A., vol. 6, 1900, p. 196).

Exmouth. Very common on the banks in the estuary, where there was a large proportion of gravel mixed with clean sand (Journ. M.B.A., vol. 6, 1902, p. 321).

Torquay. Numerous on Tor Abbey Sands, especially at the east end (*Elwes*, Journ. M.B.A., vol. 9, 1910, p. 63).

NICOLEA VENUSTULA (Montagu)? *de St. Joseph*, Ann. Sci. Nat. Zool. XVII. 1894, p. 207. *Marenzeller*, Sitzb. Kg. Akad. der. Wiss. zu Wien, Bd. 89, 1884, p. 195.

ENGLISH CHANNEL. Seven specimens obtained 32 miles S. of Start Point (40–43 fms.).

Dredged by Crawshay at a number of stations S.S.W. of the Eddystone at depths of 42–50 fms. (*Crawshay*, Journ. M.B.A., vol. 9, 1912, p. 343).

These specimens from the deeper water of the Channel all have 17 bundles of bristles on each side.

The difference between this and the next species (*Nicolea zostericola* (Oersted) Malmgren) is discussed by de St. Joseph and by Crawshay (*loc. cit.* p. 344). *N. venustula* as described by de St. Joseph has 17 setigerous segments, whereas *N. zostericola* as described by Malmgren has 15 only.

McIntosh (Ann. Mag. Nat. Hist., vol. 15, 1915, p. 20) describes *N. venustula* as having 15 bristle-bundles on each side, which would make the form described by him agree with *N. zostericola*.

Fauvel (Résult. Camp. Scient. Monaco, Fasc. XLVI. Annél. Polych. 1914, p. 299) has found both the form with 15 setigerous segments and that with 17 such segments. He considers them as the same species and adopts the name *N. venustula* (Montagu).

NICOLEA ZOSTERICOLA (Oersted): *Malmgren*, Nordiska Hafs-Annulater, Öfer. K. Vet. Akad. Förh., 1865, p. 381.

PLYMOUTH. Common between tide-marks on Reny Rocks; less frequent on the north side of Drake's Island. Also obtained from dredgings in Yealm River.

This species has 15 bundles of bristles on each side, and so far has only been recognised from the shore and shallow inshore waters. For comparison with *N. venustula* see note to that species.

THELEPUS CINCINNATUS (Fabricius): *Marenzeller*, Adriat. Annel. Sitzb. K. Akad. der Wiss. zu Wien, Bd. 89, 1884, p. 205.

PLYMOUTH. Common on the trawling grounds in the neighbourhood of the Eddystone (20 to 40 fms.).

Obtained by Crawshay at a number of stations S.S.W. of the Eddystone in depths of 40 to 50 fms. (Journ. M.B.A., vol. 9, 1912, p. 344).

If the number of pairs of gills (gills on two segments) is taken as the main character of the species, rather than the shape of the uncini, which seems variable, the species most commonly met with is *T. cincinnatus*, and not *T. setosus*, Quatrefages, as entered in the former list. It is probable that *T. setosus* also occurs in small numbers, but the matter requires re-investigation.

SALCOMBE. It is doubtful whether the species found at Salcombe should be assigned to *T. setosus* or to *T. cincinnatus* (Journ. M.B.A., vol. 6, 1900, p. 197).

POLYCIRRUS CALIENDRUM Claparède : *de St. Joseph*, Ann. Sci. Nat. Zool. XVII. 1894, p. 237.

PLYMOUTH. Common in dredgings from all parts of the Sound, especially in Millbay Channel. Dredged also in Yealm River. Occasional specimens amongst weeds and Laminaria roots from the shore.

In the former list two species *P. aurantiacus* Grube and *P. caliendrum* Claparède were recorded. The specimens included under the former name were those which are generally of large size and of a bright scarlet red colour. They have, however, three large pairs of nephridia and three small pairs as in *P. caliendrum.* The typical specimens of *P. caliendrum*, which were referred to in the former list, are of various shades of yellow, some being quite pale. They have six pairs of nephridia arranged as in the bright red form. I am inclined to agree with Southern's suggestion (Proceed. R. Irish Acad. XXXI. 47, 1914, p. 127) that *P. aurantiacus* and *P. caliendrum* may be identical, in which case the name *P. aurantiacus* Grube should have precedence. *McIntosh's* recent description of *P. aurantiacus* Grube (Ann. Mag. Nat. Hist. XV. 1915, p. 33) would appear to apply to the species now under discussion, and he speaks of a red variety.

SALCOMBE. Both varieties dredged between Salstone and Snape's Point (Journ. M.B.A., vol. 6, 1900, p. 197).

POLYCIRRUS HÆMATODES (Claparède) : *de St. Joseph*, Ann. Sci. Nat. Zool. XVII. 1894, p. 241.

PLYMOUTH. Not uncommon in dredgings from the Sound, especially from Millbay Channel and Asia Shoal. It is much less numerous than *P. caliendrum.*

LOIMIA MEDUSA (Savigny) : *Malmgren*, Nord. Hafs-Annul. 1865, p. 380, Pl. XXV ; Ann. Polych. 1867, p. 217, Pl. XIV.

PLYMOUTH. Amongst shell gravel near low-water mark on the north side of Drake's Island ; from the shore in Yealm River. Tubes dredged on Queen's Ground.

TEREBELLIDES STRŒMI, Sars : *Malmgren*, Nord. Hafs-Annul. 1865, p. 396.

PLYMOUTH. One specimen dredged four miles S.W. by S. of Rame Head.

AMPHARETIDÆ.

MELINNA ADRIATICA Marenzeller : Adriatische Anneliden. Sitzb. Akad. Wien, Bd. 69, 1874, p. 472.

PLYMOUTH. Very common in soft mud in Plymouth Sound. Found both on the shore at low water and also by dredging.

SALCOMBE. In fine mud in the upper parts of Salcombe and Kingsbridge Estuary in very great abundance. Probably the *Sabella curta* of Montagu (Journ. M.B.A., vol. 6, 1900, p. 197).

Exmouth. Only a few scattered specimens were found in the estuary (Journ. M.B.A., vol. 6, 1902, p. 322).

Torquay. Two at extreme low water at Livermead amongst *Zostera* roots (*Elwes*, Journ. M.B.A., vol. 9, 1910, p. 64).

Amphicteis Gunneri Sars : *Fauvel*, Résult. Camp. Sci. Monaco, Fas. XLVI. Annél. Polych. 1914, p. 281.

Plymouth. One specimen dredged four miles S.W. by S. of Rame Head.

Recorded in the former list as *A. curvipalea* Claparède, which Fauvel has shown to be identical with *A. Gunneri* Sars.

AMPHICTENIDÆ.

Pectinaria (Lagis) Koreni Malmgren : *de St. Joseph*, Ann. Sci. Nat. Zool. V. 1898, p. 405.

Plymouth. Common in sand near low-water mark south of Batten Castle.

Salcombe. Two specimens recorded as *P. belgica* from the shore may be this species (Journ. M.B.A., vol. 6, 1900, p. 198).

Pectinaria (Amphictene) auricoma (Müller) : *Malmgren*, Nord. Hafs-Annulat. 1865, p. 357.

Plymouth. Eddystone Grounds (t.v.h.).

Pectinaria (Petta) pusilla Malmgren : Nord. Hafs-Annul. 1865, p. 361. *Fauvel*, Résult. Camp. Sci. Monaco, Fasc. XLVI. Annél. Polych. 1914, p. 279.

Plymouth. Two specimens dredged by Crawshay S.S.W. of the Eddystone in 42 fms. (Journ. M.B.A., vol. 9, 1912, p. 346).

CAPITELLIDÆ.

Notomastus latericeus Sars : *McIntosh*, Mon. Brit. Ann. III. 1, 1915, p. 276.

Plymouth. On the shore in black, muddy sand near low-water mark in the upper parts of the Yealm Estuary. Occasional specimens from the shore at Rum Bay and Wembury Bay.

Salcombe. One of the commonest Polychætes of the shores of the estuary. Especially abundant and large in the fine mud in the upper parts of the estuary (Journ. M.B.A., vol. 6, 1900, p. 194).

Torquay. Under stones, Corbyn's Head and Livermead (*Elwes*, Journ. M.B.A., vol. 9, 1910, p. 64).

Notomastus rubicundus Keferstein : *Eisig*, Die Capitelliden des Golfes von Neapel, 1887, p. 863.

Plymouth. In fine clean sand on the north and south shores of the Yealm Estuary, near the mouth. In fine clean sand at Wembury Bay.

Prof. McIntosh considers that these are young *N. latericeus*. The appearance of the living worms is, however, quite distinct, and both the habits and the habitat of the two forms are different. *N. latericeus* burrows by constantly protruding the proboscis and when examined alive it is continually performing this movement. In the case of *N. rubicundus*, although many specimens have been watched, I have never yet seen the proboscis protruded.

CAPITELLA CAPITATA (Fabricius): *McIntosh*, Mon. Brit. Ann. III. 1, 1915, p. 280.

PLYMOUTH. Common in black mud from between tide-marks, Wembury Bay and Rum Bay.

HETEROMASTUS FILIFORMIS Claparède: *Eisig*, Die Capitelliden des Golfes von Neapel, 1887, p. 839.

EXMOUTH. A few specimens in the sand west of Salthouse Lake (Journ. M.B.A., vol. 6, 1902, p. 320).

OPHELIIDÆ.

OPHELIA BICORNIS Savigny: *de St. Joseph*, Ann. Sci. Nat. Zool. V. 1898, p. 380.

EXMOUTH. Very abundant in clean sand on the Pole Sands. Occasionally met with on other sand-banks (Journ. M.B.A., vol. 6, 1902, p. 321).

A considerable number of specimens have recently been examined and they have been compared with typical specimens of *O. limacina* Rathke from the North Sea. The distinguishing characters described by de St. Joseph are remarkably constant and there is no doubt that the two species are quite distinct. The list of synonyms of *O. limacina* given by McIntosh (Mon. III. 1, 1915, p. 10) therefore requires revision in the sense indicated by de St. Joseph. In the first region of the body of *O. bicornis* there are 9 setigerous segments, then follow 15 setigerous segments bearing gills or dorsal processes, and behind these five setigerous segments without gills, and one achetous anal segment. A constant character of the species not mentioned by de St. Joseph is a lateral, vertical, glandular fold of skin, which lies immediately in front of the 9th parapodium. The lips of the parapodia are much less strongly developed than in *O. limacina* and all the bristles are much shorter, more slender and inconspicuous. The lateral rows of pores immediately above the gills described by de St. Joseph in *Ophelia neglecta* Schneider, which are very conspicuous in the large specimens of *O. limacina* (cf. de St. Joseph, p. 379) are entirely absent in *O. bicornis*.

AMMOTRYPANE AULOGASTER Rathke: *McIntosh*, Mon. Brit. Ann. III. 1, 1915, p. 15.

PLYMOUTH. Occasionally dredged in the Sound, and on the Mewstone shell gravel.

POLYOPHTHALMUS PICTUS Dujardin : *McIntosh*, Mon. Brit. Ann. III. 1, 1915, p. 21.

PLYMOUTH. On the shore between tide-marks Wembury Bay (A.J.S.) ; occasionally found on all rocky shores amongst the weed and coralline of tide pools.

TORQUAY. Common amongst Corallines, etc., in rock pools (*Elwes*, Journ. M.B.A., vol. 9, 1910, p. 64).

MALDANIDÆ.

MICROMALDANE ORNITHOCHÆTA Mesnil : Bull. Sci. France et Belg. XXX. 1897, p. 146. *Southern*, Proceed. R. Irish Acad. XXXI. 47, 1914, p. 134.

PLYMOUTH. Found once on the shore at Rum Bay.

NICOMACHE LUMBRICALIS (Fabricius) *var.* : *Arwidsson*, Zool. Jahrb. Abt. Systematik. Suppl. 9, Hft. 1, 1907, p. 86.

PLYMOUTH. One specimen was obtained amongst trawled material from the Rame-Eddystone Ground.

The specimen is in three pieces, but no portion seems to be missing. Its total length would be about 260 mm. There are 21 setigerous segments and *three* pre-anal achetous segments. The anal funnel resembles Arwidsson's figure. The anterior border of the head has not a broad, hemispherical outline, but is produced into a slight but distinct blunt projecting process. This is not the *Nicomache maculata* Arwidsson, which is the only British *Nicomache* recorded in recent publications by McIntosh and Southern.

CÆSICIRRUS NEGLECTUS Arwidsson : Proceed. Roy. Irish Acad. XXIX. B. 6, 1911, p. 217.

PLYMOUTH. In sand and amongst roots of *Zostera* at the mouth of the Yealm Estuary.

SALCOMBE. Common in the *Zostera* beds near the mouth of the estuary.

HETEROCLYMENE ROBUSTA Arwidsson : Zool. Jahrb. Abt. Systematik. Suppl. 9, Hft. 1, 1907, p. 227.

PLYMOUTH. Occasionally met with amongst trawled material from the Rame-Eddystone Grounds.

ARENICOLIDÆ.

ARENICOLA MARINA Linnaeus : *McIntosh*, Mon. Brit. Ann. III. 1, 1915, p. 59.

PLYMOUTH. In fine sand between tide-marks at Rum Bay, Drake's Island, Mount Edgcumbe, Wembury Bay and Yealm River (T.V.H., R.A.T., E.J.A.).

Post-larval stages of *Arenicola* in townettings in February (W.G., W.B.B.) and March (E.J.A.).

SALCOMBE. Common in all parts of the harbour in sand or muddy sand (Journ. M.B.A., vol. 6, 1900, p. 195).

EXMOUTH. Very abundant in sand and gravel in the estuary (Journ. M.B.A., vol. 6, 1902, p. 321).

TORQUAY. Common on Tor Abbey Sands (*Elwes*, Journn. M.B.A., vol. 9, 1910, p. 64).

ARENICOLA ECAUDATA Johnston: *McIntosh*, Mon. Brit. Ann. III. 1, 1915, p. 72.

PLYMOUTH. With *A. branchialis* near the bases of rocks in a deposit composed of sand and small stones (F.W.G.); Rum Bay, in sand and gravel around the rocks below the Laboratory (R.A.T.); Wembury Bay (R.A.T., E.J.A.); Drake's Island (T.V.H.).

TORQUAY. Under stones in gravel at Hope's Nose and Babbacombe Beach (*Elwes*, Journ. M.B.A., vol. 9, 1910, p. 64).

ARENICOLA BRANCHIALIS Audouin and Edwards: *McIntosh*, Mon. Brit. Ann. III. 1, 1915, p. 78. *Ashworth*, Cat. Chætopoda Brit. Museum I. 1912, p. 141.

PLYMOUTH. With *A. ecaudata* near the bases of rocks in a deposit composed of sand and small stones (F.W.G.); Rum Bay, Wembury Bay, Drake's Island.

Recorded in the former list as *A. Grubei* Claparède.

SALCOMBE. One specimen only found in muddy gravel on the west side of the Salstone (Journ. M.B.A., vol. 6, 1900, p. 195 as *A. Grubii*).

SCALIBREGMIDÆ.

SCALIBREGMA INFLATUM Rathke: *McIntosh*, Mon. Brit. Ann. III. 1, 1915, p. 34.

PLYMOUTH. In muddy gravel at low water on the southern shore of the Yealm River, just below the junction of the two rivers; two specimens 10/9/00. No further specimens of this species have been taken.

SCLEROCHEILUS MINUTUS Grube: *McIntosh*, Mon. Brit. Ann. III. 1, 1915, p. 43.

PLYMOUTH. This species was formerly frequently taken in Millbay Channel dredgings, and occasionally in dredgings from Asia Shoal and off the Mewstone. During the last two or three years no specimens have been found in spite of special search for it.

CHLORHÆMIDÆ.

STYLARIOIDES (TROPHONIA) PLUMOSA (O. F. Müller): *McIntosh*, Mon. Brit. Ann. III. 1, 1915, p. 231.

PLYMOUTH. In dredgings from Millbay Channel and Asia Shoal, occasional specimens. Also dredged off Stoke Point.

FLABELLIGERA (SIPHONOSTOMA) AFFINIS Sars: *McIntosh*, Mon. Brit. Ann. III. 1, 1915, p. 107.

PLYMOUTH. Between tide-marks at Drake's Island (R.A.T., T.V.H., E.J.A.); Reny Rocks (R.A.T., E.J.A.); under Rame Head (T.V.H.); Wembury Bay (E.J.A., A.J.S.); in dredgings from Millbay Channel, Queen's Ground (R.A.T., T.V.H.); Mewstone Grounds (E.J.A., R.A.T.); on *Echinus acutus* (R.A.T.).

TORQUAY. Under stones at Corbyn's head (*Elwes*, Journ. M.B.A., vol. 9, 1910, p. 64).

SABELLIDÆ.

SABELLA PAVONINA (Savigny): *de St. Joseph*, Ann. Sci. Nat. Zool. XVII. 1894, p. 267.

PLYMOUTH. Common on the shore in Yealm River and also found in Yealm dredgings. Common on the shore in the Cattewater, near the entrance to Hooe Lake. Looe-Eddystone, Rame-Eddystone and Eddystone Grounds, common amongst hydroids and Cellaria.

Dredged by Crawshay S.S.W. of the Eddystone at a number of positions in depths of 40 to 51 fms. (Journ. M.B.A., vol. 9, 1912, p. 346).

Specimens from the deeper water are all small with the tube of very fine mud, compact and light coloured. Those on the shore attain a large size and the tube is much coarser.

Breeding: August and September (C.S.).

SALCOMBE. Very abundant on the shore at the Salstone, and on the mud in Kingsbridge Estuary south of Garston Point. Absent from the banks near the mouth of Salcombe Harbour (Journ. M.B.A., vol. 6, 1900, p. 198). These estuarine specimens were of large size.

TORQUAY. Large specimens from the inner harbour. (*Elwes*, Journ. M.B.A., vol. 9, 1910, p. 65).

BRANCHIOMMA VESICULOSUM (Montagu): *de St. Joseph*, Ann. Sci. Nat. Zool. XVII. 1894, p. 300.

PLYMOUTH. Occasional specimens on the shore, Yealm sandbank and Rum Bay (R.A.T.): Drake's Island, south shore of Yealm near the mouth, Barn Pool, and shore south of Batten Castle.

SALCOMBE. In Salcombe Estuary where the soil is composed of gravel, abundant. It is found at a higher tidal level than *Sabella pavonina* and *Myxicola infundibulum*. Most numerous on the

Salstone and in the upper parts of Salcombe Harbour (Journ. M.B.A., vol. 6, 1900, p. 199).

Dasychone bombyx (Dalyell): *de St. Joseph*, Ann. Sci. Nat. Zool. XVII. 1894, p. 309.

Plymouth. Amongst Laminaria roots from the shores of the Sound and amongst Ascidians from Millbay Dock. Occurs on all the dredging grounds in the Sound, and outside to Eddystone Grounds.

Dredged by Crawshay at a number of positions S.S.W. of the Eddystone in depths of 40–49 fms. (Journ. M.B.A., vol. 9, 1912, p. 346).

Potamilla reniformis (O. F. Müller): *de St. Joseph*, Ann. Sci. Nat. Zool. XVII. 1894, p. 292.

Plymouth. Large specimens from the shore at Rum Bay and Jennycliff Bay in crevices of shale. Occurs also attached to rocks below the Laboratory, at Wembury Bay and other rocky shores. Not uncommon in holes in limestone from Plymouth Breakwater.

Torquay. On the sides of a cave at Petit Tor (*Elwes*, Journ. M.B.A., vol. 9, 1910, p. 65).

Potamilla Torelli Malmgren: *de St. Joseph*, Ann. Sci. Nat. Zool. XVII. 1894, p. 296.

Plymouth. Common in dredgings from Millbay Channel, Asia Shoal and Yealm River.

In the former list *Potamilla incerta* Langerhans, found in dredgings from the Yealm River, was recorded. Fauvel considers this form to be a young stage of *P. Torelli.*

Torquay. Common in small rock pools in the limestone rocks between Oddicombe and Babbacombe beaches (*Elwes*, Journ. M.B.A., vol. 9, 1910, p. 65).

Bispira volutacornis (Montagu): *de St. Joseph*, Ann. Sci. Nat. Zool. XVII. 1894, p. 286.

Plymouth. In cracks between rocks at extreme low-tide mark on Reny Rocks and in Jennycliff Bay.

Myxicola infundibulum (Renier): *de St. Joseph*, Ann. Sci. Nat. Zool. V. 1898, p. 433.

Plymouth. Found occasionally on the shore. North side of Drake's Island (R.A.T.); Barn Pool (E.J.A.); Ram's Cliff Point (S.P.).

Salcombe. Very frequent on all parts of the Salstone and on the *Zostera* flat immediately to the south of Pilworthy Point. Occasional specimens in the lower parts of Salcombe Harbour (Journ. M.B.A., vol. 6, 1900, p. 199).

Myxicola (Leptochone) æsthetica Claparède: Annél. Chétop. Naples, Supplément, 1870, p. 150.

Plymouth. Common in dredgings from Millbay Channel and

Asia Shoal. Occasional specimens in dredgings from all parts of the Sound. From the shore at Rum Bay in crevices of shale.

AMPHIGLENA MEDITERRANEA Leydig: *de St. Joseph*, Ann. Sci. Nat. Zool. XVII. 1894, p. 307.

PLYMOUTH. Amongst Laminaria roots from the rocks below the Laboratory. In crevices of shale at Wembury Bay.

TORQUAY. From roots of Laminaria and pieces of limestone rock (*Elwes*, Journ. M.B.A., vol. 9, 1910, p. 65).

JASMENEIRA ELEGANS de St. Joseph: Ann. Sci. Nat. Zool. XVII. 1894, p. 316.

PLYMOUTH. Amongst dredgings from Duke Rock and Asia Shoal.

TORQUAY. From roots of Laminaria and pieces of limestone rock (*Elwes*, Journ. M.B.A., vol. 9, 1910, p. 65).

FABRICIA SABELLA Ehrenberg: *de St. Joseph*, Ann. Sci. Nat. Zool. XVII. 1894, p. 319.

PLYMOUTH. Very abundant amongst mud scraped from piles at Millbay Dock.

Breeding. February.

TORQUAY. Very common in little pools in the rocks at Babbacombe (*Elwes*, Journ. M.B.A., vol. 9, 1910, p. 65).

ORIA ARMANDI Claparède: *de St. Joseph*, Ann. Sci. Nat. Zool. XVII. 1894, p. 321.

PLYMOUTH. Amongst Ascidians from the piles at Millbay Dock.

TORQUAY. One specimen from Babbacombe rock pools (*Elwes*, Journ. M.B.A., vol. 9, 1910 p. 65).

HAPLOBRANCHUS ÆSTUARIUS Bourne: Quart. Journ. Micr. Sci. XXIII. 1883, p. 169.

PLYMOUTH. In tide pools not far from the mouth of the Yealm (*Buchanan*, Rep. Brit. Assoc. 1892, p. 359).

SERPULIDÆ.

SERPULA VERMICULARIS Linnæus: *de St. Joseph*, Ann. Sci. Nat. Zool. XVII. 1894, p. 328.

PLYMOUTH. Occasional specimens in the Sound. In small numbers from Mewstone Grounds, Looe-Eddystone, Rame-Eddystone and Eddystone Grounds.

Obtained at a number of positions S.S.W. of the Eddystone in depths of 42 to 49 fms. (*Crawshay*, Journ. M.B.A., vol. 9, 1912, p. 346).

Large masses of this species were obtained by a diver somewhere in the Hamoaze and brought to the Laboratory.

Breeding. Specimens from Eddystone Grounds in August and September were ripe (c.s.).

TORQUAY. On shells thrown up on the shore at Tor Abbey Sands (*Elwes*, Journ. M.B.A., vol. 9, 1910, p. 66).

POMATOCEROS TRIQUETER (Linnæus): *de St. Joseph*, Ann. Sci. Nat. Zool. XVII. 1894, p. 353.

PLYMOUTH. Common, attached to shells and stones on all grounds from the shore to 30 fms.

Dredged by Crawshay at several positions S.S.W. of the Eddystone in depths of 42–51 fms. (Journ. M.B.A., vol. 9, 1912, p. 347).

SALCOMBE. Common in dredge material from Salcombe Harbour and the Kingsbridge Estuary (Journ. M.B.A., vol. 6, 1900, p. 199).

EXMOUTH. Found only at Orcombe Rocks, at the mouth of the estuary (Journ. M.B.A., vol. 6, 1902, p. 322).

TORQUAY. Extremely common on stones (*Elwes*, Journ. M.B.A., vol. 9, 1910, p. 66).

HYDROIDES NORVEGICA Gunnerus: *de St. Joseph*, Ann. Sci. Nat. Zool. V. 1898, p. 440.

PLYMOUTH. Common on stones and shells from the shore to 30 fms., increasing in abundance in the deeper water.

Dredged by Crawshay at a number of positions S.S.W. of the Eddystone in depths of 40–49 fms. (Journ. M.B.A., vol. 9, 1912, p. 347).

Breeding. August (C.S.).

TORQUAY. On a stone at Petit Tor Beach; numerous on buoys in Torquay Harbour (*Elwes*, Journ. M.B.A., vol. 9, 1910, p. 66).

FILOGRANA IMPLEXA (Berkeley): *de St. Joseph*, Ann. Sci. Nat. Zool. XVII. 1894, p. 335; ditto, p. 340 as *Salmacina Dysteri* Huxley.

PLYMOUTH. In quantity from Millbay Channel, from the piles of the Promenade Pier (E.J.A.); on piles at the entrance to Millbay Dock (R.A.T.); on the Breakwater (T.V.H.). Occasionally met with in all dredgings from the Sound and on the outer grounds to the Eddystone.

Recorded by Crawshay at three stations S.S.W. of the Eddystone in 42–43 fms. (Journ. M.B.A., vol. 9, 1912, p. 347).

The distinction given by de St. Joseph and others between Filograna and Salmacina is that the former has opercula, whilst the latter has not. McIntosh considers the two forms the same, a view which is accepted by Cunningham and Ramage (Trans. Roy. Soc. Edin. XXXIII. 1888, p. 673) and by Southern (Proceed. R. Irish Acad. XXXI. 47, 1914, p. 147). The Plymouth specimens, of which a considerable number have been specially examined, have been without opercula.

Breeding. July, August and September (C.S.).

SPIRORBIS BOREALIS Daudin: *de St. Joseph*, Ann. Sci. Nat. Zool. XVII. 1894, p. 345.

PLYMOUTH. Common on weeds, especially Fucus, and on stones on all shores.

SALCOMBE. Common in dredge material from Salcombe Harbour and the Kingsbridge Estuary (Journ. M.B.A., vol. 6, 1900, p. 199).

TORQUAY. Very common on Fucus (*Elwes*, Journ. M.B.A., vol. 9, 1910, p. 66).

SPIRORBIS SPIRILLUM Linnæus : *Caullery and Mesnil*, Bull. Sci. France et Belg. XXX. 1897, p. 198.

PLYMOUTH. Dredged by Crawshay at a number of positions S.S.W. of the Eddystone in 42–51 fms. It occurred commonly on Hydroids, especially on *Sertularia abietina* (Journ. M.B.A., vol. 9, 1912, p. 347).

TORQUAY. On *Sertularia abietina* thrown up on the shore (*Elwes*, Journ. M.B.A., vol. 9, 1910, p. 66).

PROTULA TUBULARIA (Montagu) : *de St. Joseph*, Ann. Sci. Nat. Zool. XVII. 1914, p. 362.

PLYMOUTH. Found on Mewstone Grounds, Rame-Eddystone Grounds and Eddystone Grounds (R.A.T., E.J.A.).

Dredged by Crawshay at four positions S.S.W. of the Eddystone in depths of 42–49 fms. (Journ. M.B.A., vol. 9, 1912, p. 347).

Breeding. Females with ripe eggs from Eddystone Grounds in June (A.J.S.)., August and September (C.S.).

HERMELLIDÆ.

SABELLARIA ALVEOLATA (Linnæus) : *de St. Joseph*, Ann. Sci. Nat. Zool. XVII. 1894, p. 160.

PLYMOUTH. Common attached to rocks on sandy shores at Whitsand Bay.

EXMOUTH. Very common at Orcombe Rocks at the mouth of the estuary, forming the usual reef-like masses (Journ. M.B.A., vol. 6, 1902, p. 322).

TORQUAY. Very common on all the Torquay coast (*Elwes*, Journ. M.B.A., vol. 9, 1910, p. 66).

SABELLARIA SPINULOSA Leuckart : *de St. Joseph*, Ann. Sci. Nat. Zool. XVII. 1894, p. 154.

PLYMOUTH. Occasional specimens attached to shells, etc., from all dredging grounds in the Sound, and from outside dredging and trawling grounds to the Eddystone.

Found in small numbers at many positions S.S.W. of the Eddystone by Crawshay (Journ. M.B.A., vol. 9, 1912, p. 348).

Breeding. May (W.G.) ; September (E.J.A.).

PALLASIA MURATA Allen : Journ. Mar. Biol. Assocn. vol. 7, 1904, p. 299.

PLYMOUTH. Two or three specimens have been obtained from gravel off Stoke Point and from shell gravel near the Mewstone. Empty tubes are frequently found on the latter ground.

Crawshay obtained tubes or portions of tubes at a large number of positions S.S.W. of the Eddystone in depths of 40 to 50 fms. Living specimens were obtained at three positions, the largest number being at Position 17, situated 23·3 miles S. 28° W. of the Eddystone, at a depth of 45 fms., where portions of six worms were taken (Journ. M.B.A., vol. 9, 1912, p. 348).

Marine Biological Association of the United Kingdom.

Report of the Council, 1914.

The Council and Officers.

Four ordinary meetings of the Council were held during the year, at which the average attendance was ten. A committee of the Council visited and inspected the Plymouth Laboratory.

The Council has to record with regret the death of the Rt. Hon. Joseph Chamberlain, M.P., a Vice-President of the Association and one of its earliest supporters.

The meetings of Council have been held in the rooms of the Royal Society at Burlington House, and the thanks of the Association are tendered to the Royal Society for the use of these rooms.

The Plymouth Laboratory.

The buildings, fittings and machinery at Plymouth have been maintained in a state of good repair, without any exceptional expenditure being incurred during the year. It will soon be necessary to provide more accommodation for the Library, as the present room contains as many books as can be stored there with safety.

The Boats.

The *Oithona* was in commission during the first eight months of the year and is in good condition. She was laid up at the end of August. The new sailing boat, built last year, has continued to give satisfaction, being a powerful sea boat for her size and easily handled. The small motor-boat remains in our possession, but has not been much used during the year.

The Staff.

The members of the permanent staff are as follows: Director, Dr. E. J. Allen; Hydrographer, Mr. D. J. Matthews; Naturalists, Messrs. L. R. Crawshay and E. W. Nelson, Dr. J. H. Orton and Mr. R. S. Clark; Assistant Naturalist, Mr. E. Ford.

At the beginning of August Mr. R. S. Clark volunteered, at short notice, to join Sir Ernest Shackleton's Antarctic Expedition, to take the place of the marine biologist to the expedition who had been called up for military service. Subsequently Mr. Nelson and Mr. Ford both joined His Majesty's Forces for the period of the war, so that during the later months of the year the staff was considerably reduced in strength. Dr. Orton has taken charge of the fishery work during Mr. Clark's absence.

Occupation of Tables.

The following Naturalists have occupied tables at the Plymouth Laboratory during the year :—

Miss Bartholomew, Oxford (Parasitic Triclad on Lobster).
Prof. G. C. Bourne, f.r.s., Oxford (Corals).
E. T. Browne, b.a., Berkhamsted (Hydrozoa).
J. T. Cunningham, m.a., London (Polychæta).
W. De Morgan, Plymouth (Protozoa).
A. N. Drury, b.a., Cambridge (Physiology of Fishes).
J. S. Dunkerly, b.sc., Glasgow (Myxosporidia).
H. M. Fuchs, b.a., London (Echinoderm Hybrids).
Dr. E. S. Goodrich, f.r.s., Oxford (Parasitic Protozoa).
Mrs. Goodrich, Oxford (Parasitic Protozoa).
F. M. Gossen, Plymouth (Fishes).
J. Gray, b.a., Cambridge (Electrical Conductivity of Echinus Eggs).
Dr. S. Hatta, Japan (Embryology).
Dr. Herbert Henry, Sheffield (Blood Parasites of Fishes).
A. G. Huntsman, Toronto (Tunicata).
Miss M. Irwin, b.a., Cambridge (Embryology).
W. O. R. King, m.a., Ray Lankester Investigator (Echinoderms).
Mrs. W. O. R. King, Leeds (Echinoderms).
Dr. P. L. Kramp, Copenhagen (Hydrozoa).
Mrs. D. J. Matthews, m.sc., Plymouth (Development of Alcyonium).
J. T. Saunders, m.a., Cambridge (Alkalinity of Sea-water).
Dr. H. D. Senior, New York (Elasmobranchs).
Mrs. E. W. Sexton, Plymouth (Amphipoda and Polychæta).
Dr. C. Shearer, m.a., Cambridge (Echinus).
Miss A. W. Thomson, Oxford (Nicothoe).
Dr. J. Stuart Thomson, Manchester (Brain of Selachians).
H. G. Thornton, b.a., Oxford (Protozoa).
Dr. Otto Warburg, Berlin (Echinus).
R. W. Watkins, New York (Elasmobranchs).
P. Worthington, Oxford (Parasitic Triclad on Lobster).

In addition to the above, the usual Easter Vacation Course in Marine Biology was conducted by Dr. J. H. Orton, and was attended by sixteen students. Mr. J. T. Cunningham, m.a., brought a class of six students from the South-Western Polytechnic, Chelsea, at Whitsuntide.

General Work at the Plymouth Laboratory.

The two numbers of the Journal issued during the year (Vol. x., Nos. 2 and 3) contain several important reports upon investigations carried out in the Laboratory. Mr. R. S. Clark's report on the Larval and Post-Larval Teleosteans in Plymouth waters records the results of work which has been in progress for some years, and Mr. Clark has been able to describe from the material collected by the Association many interesting stages in the life-histories of fishes belonging to a number of different families. Some of these stages are illustrated for the first time by careful drawings, which were made by the Assistant Naturalist, Mr. E. Ford. Incidentally the records of occurrence of the larval fishes give useful indications as to the time and duration of the spawning season of many different species of fishes in the western part of the English Channel.

A paper by the Director on the culture of the plankton diatom *Thalassiosira gravida* in artificial sea-water gives an account of a series of experiments made with a view to studying the exact conditions most favourable to the growth of such organisms, which, as is well known, form one of the fundamental sources of the food-supply of the sea, the first step of the food-chain leading from inorganic substances, through the invertebrate animals of the plankton and the bottom fauna to the fishes. Dr. Allen has been able to show that good cultures cannot be obtained in a purely artificial medium made by dissolving pure chemicals in doubly distilled water in the proportions in which the salts occur in sea-water with the addition of nitrates, phosphates and iron. If, however, a small percentage of natural sea-water, even as little as 1 per cent, be added and the solution sterilized, excellent cultures result after inoculation with the diatom. The result appears to be due to some specific substance present in minute quantity in the natural sea-water which acts as a growth stimulant. The actual nature of this substance has, however, not yet been determined. Provided the small quantity of natural sea-water be present in the culture medium the other constituents can be varied within wide limits and the salinity of the medium can also be considerably altered without damaging the growth.

The Council particularly desires to draw the attention of the members of the Association to the high scientific value and general interest of this paper. Dr. Allen's results are somewhat analogous to discoveries made in the department of human physiology, which suggest that it is necessary to the life of the higher animals that there should be present in their food small quantities of obscure chemical substances which have been given the name of vitamines.

Dr. J. H. Orton gives an interesting account of the mechanism by means of which the Brachiopods and certain Polychæte worms produce the currents which supply these animals with food and with a supply of water for respiration. The arrangement of the cilia, to the action of which the currents are due, is carefully described, as is also the direction and use of the different currents themselves. It is shown that the ciliary mechanisms on the gills of many Gastropods, most Lamellibranchs, Amphioxus, Ascidians, Brachiopods and Cryptocephalous Polychætes are essentially similar in character.

In a second paper Dr. Orton gives an account of certain Holothurians, which are common at Plymouth, describing in some detail the characters by which they can be differentiated, and recording some observations on their habits. Other papers by the same author deal with the breeding habits of the sea-urchin, *Echinus miliaris*, the feeding habits of the limpet, *Patella vulgata*, and with certain features of the life-history of Amphioxus.

Dr. Orton also gives a preliminary account of his work on the rate of growth of invertebrates and the age at which they commence to breed for the first time. This investigation when completed promises to be of considerable importance from a practical as well as from a theoretical point of view.

The Council desire to congratulate Dr. Orton on attaining the degree of D.Sc. at the University of London, which was awarded upon the researches which he has carried out at the Plymouth Laboratory.

The Journal also contains three papers by Prof. E. L. Bouvier, of the Paris Natural History Museum, which are the outcome of the work he did at the Laboratory as first "Ray Lankester Investigator" during the summer of 1913. Prof. Bouvier's work on the life-history of the sea-crayfish (*Palinurus vulgaris*) was referred to in the Council's Report for last year, and need not therefore be further described. His other papers deal with observations on the Crustacean larva, *Trachelifer*, and on variation in *Pycnogonum littorale*.

During the first half of the present year Mr. Clark continued his investigations on the mackerel fishery off the Cornish coast. A considerable body of valuable information has been collected bearing on the migrations and feeding habits of this fish. The work upon larval and post-larval fishes was also continued.

Mr. D. J. Matthews has been studying the chemical composition of sea-water, devoting himself for the most part to the elaboration of a method for the accurate estimation of the nitrates.

Mr. L. R. Crawshay has been continuing with marked success experiments upon keeping alive and rearing in the Laboratory some of the more delicate plankton animals. This work is important as a general study, which should lead to a better understanding of the right conditions which should be adopted for the rearing of sea fishes, molluscs and crustaceans.

Mr. W. O. R. King, of the University of Leeds, was appointed Ray Lankester Investigator for 1914, and has been engaged in studies on the physiology of Echinoderm development. The two subjects to which he gave special attention were a determination of the temperature coefficient of development of Echinus and a study of the enzymes present in the gonads of the same animal. Mr. King was assisted on the chemical side of the investigations by Mrs. King.

Mrs. Matthews has completed the study of the development of *Alcyonium*, upon which she has been engaged for some time, and a paper on the subject will shortly be published.

Mr. E. T. Browne, who hired the steamer *Oithona* for some weeks last winter, and thus enabled us to keep the vessel in commission during the whole winter, spent some time at the Laboratory in connection with his work on hydroids and medusæ. Several interesting species were obtained, some of which had not been recorded previously from British waters.

Mrs. Sexton has given much assistance to the work which Dr. Allen is carrying out on the Plymouth Polychætes, by making a series of excellent coloured drawings of many of the rarer species. On her own account she has been carrying out experiments on Mendelian inheritance of eye colour in the Amphipod, *Gammarus chevreuxi*.

Mr. W. De Morgan is continuing to study the local Protozoa.

Published Memoirs.

The following papers, either wholly or in part the outcome of work done at the Laboratory, have been published elsewhere than in the Journal of the Association :—

CRAWSHAY, L. R. *Report on the Distribution of the Microplankton.* (Report on the work carried out by the s.s. *Scotia,* 1913, pp. 68–126, plates 23–35.) H.M. Stationery Office, London, 1914.

DENDY, A. *Observations on the Gametogenesis of Grantia compressa.* Quart. Journ. Micr. Sci., vol. 60, 1914, pp. 313–76.

LEIGH-SHARPE, W. H. *Calliobdella Lophii,* Parasitology, vol. 7, 1914, pp. 204–18.

LLOYD, D. JORDAN. *The Influence of Osmotic Pressure upon the Regeneration of Gunda ulvæ.* Proceed. Roy. Soc., vol. 88, 1914, pp. 1–20.

Matthews, D. J. *Hydrographical Observations in the Labrador Current in 1913.* (Report on the work carried out by the s.s. *Scotia*, 1913.) H.M. Stationery Office, London, 1914.

Sexton, E. W. *On a Collection of Gammarus from the Königsberg Museum.* Schriften Physik-oekonom. Gesellsch. Königsberg, vol. 54, 1913, pp. 90–4.

Svedelius, N. *Über die Tetradenteilung in den vielkernigen Tetrasporangiumanlagen bei Nitophyllum punctatum.* Ber. Deut. Bot. Ges., Bd. xxxii., 1914, pp. 48–57.

Svedelius, N. *Über sporen an Geschlechts-pflanzen von Nitophyllum punctatum.* Bericht. Deut. Bot. Ges., Bd. xxxii., 1914, pp. 106–16.

The Library.

The thanks of the Association are due to numerous Government Departments, Universities, and other institutions at home and abroad for copies of books and current numbers of periodicals presented to the Library during the year. The list is similar to that published in the Report of the Council for last year. A number of authors have also been good enough to send reprints of their papers for the Library, which is gradually building up a collection of great value of separate works dealing with marine subjects. As these are all catalogued separately in the Library they become readily available for use by workers in the Laboratory.

Donations and Receipts.

The receipts for the year include the grants from His Majesty's Treasury (£1000) and the Board of Agriculture and Fisheries, Development Fund (£500), Fishmongers' Company (£600), Special Donations (£5), Annual Subscriptions (£149), Rent of Tables in the Laboratory (£118), Sale of Specimens (£460), Admission to Tank Room (£119).

Vice-Presidents, Officers, and Council.

The following is the list of gentlemen proposed by the Council for election for the year 1915–16 :—

President.

Sir E. Ray Lankester, K.C.B., LL.D., F.R.S.

Vice-Presidents.

The Duke of Bedford, K.G.
The Earl of Ducie, F.R.S.
The Earl of Stradbroke, C.V.O., C.B.
Lord Montagu of Beaulieu.
Lord Walsingham, F.R.S.
The Right Hon. A. J. Balfour, M.P., F.R.S.
The Right Hon. Austen Chamberlain, M.P.
W. Astor, Esq., M.P.
G. A. Boulenger, Esq., F.R.S.
A. R. Steel-Maitland, Esq., M.P.
Rev. Canon Norman, D.C.L., F.R.S.
Edwin Waterhouse, Esq.

Members of Council.

E. T. Browne, Esq.
L. W. Byrne, Esq.
Prof. H. J. Fleure, D.Sc.
Dr. E. S. Goodrich, F.R.S.
Sir Eustace Gurney.
Prof. J. P. Hill, D.Sc., F.R.S.
E. W. L. Holt, Esq.
Prof. E. W. MacBride, D.Sc., F.R.S.
H. G. Maurice, Esq.
Dr. P. Chalmers Mitchell, F.R.S.
C. C. Morley, Esq.
F. A. Potts, Esq.
Geoffrey W. Smith, Esq.
Prof. D'Arcy W. Thompson, C.B.

Chairman of Council.

A. E. Shipley, Esq., D.Sc., F.R.S.

Hon. Treasurer.

J. A. Travers, Esq., Tortington, Arundel.

Hon. Secretary.

E. J. Allen, Esq., D.Sc., F.R.S., The Laboratory, Citadel Hill, Plymouth.

The following Governors are also members of the Council:—

G. P. Bidder, Esq.
George Evans, Esq. (Prime Warden of the Fishmongers' Company).
The Earl of Portsmouth (Fishmongers' Company).
Sir Richard Martin, Bart. (Fishmongers' Company).
The Hon. Nathaniel Charles Rothschild (Fishmongers' Company).
Prof. G. C. Bourne, D.Sc., F.R.S. (Oxford University).
A. E. Shipley, Esq., D.Sc., F.R.S. (Cambridge University).
Prof. W. A. Herdman, D.Sc., F.R.S. (British Association).

THE MARINE BIOLOGICAL ASSOCIATION

Dr. *Statement of Receipts and Payments for*

	£	s.	d.	£	s.	d.
To Balance from Last Year :—						
Cash at Bankers	540	13	4			
Cash in hand	4	2	6	544	15	10
,, Current Receipts :—						
H.M. Treasury for year ending 31st March, 1915	1,000	0	0			
The Worshipful Company of Fishmongers	600	0	0			
Annual Subscriptions received	149	1	0			
Rent of Tables (including Ray Lankester Trustees, £20 ; University of Cambridge, £25 ; University of London, £25)	118	4	0			
Interest on Investments	15	8	9	1,882	13	9
,, Extraordinary Receipts :—						
Donations—						
Dr. E. Schuster	5	0	0			
G. H. Fox	0	10	6			
J. F. Croonan	0	5	0			
	5	15	6			
Board of Agriculture and Fisheries, Grant from Development Fund for year ending 31st March, 1915	500	0	0			
Grant for Herring Investigations	50	0	0	555	15	6

The Association's Bankers hold on its behalf £410 14s. 8d. New Zealand 4 % Stock, 1943–63.

	£	s.	d.
	£2,983	5	1

OF THE UNITED KINGDOM.

the Year ending 31*st December*, 1914. Cr.

				£	s.	d.	£	s.	d.
By Salaries and Wages—									
Director				300	0	0			
Hydrographer				120	16	8			
Senior Naturalist				220	16	8			
Second Naturalist				116	13	4			
Additional Naturalist				116	11	4			
Assistant Naturalist				142	11	7			
Salaries and Wages				754	14	1	1,772	3	8
,, Travelling Expenses							64	0	
,, Library				98	12	5			
Less Duplicates sold				17	0	8	81	11	9
,, Journal				116	9	3			
Less Sales				17	3	7	99	5	8
,, Buildings and Public Tank Room—									
Gas, Water, and Coal				104	11	5			
Stocking Tanks and Feeding				50	19	4			
Maintenance and Renewals				52	9	1			
Rent, Rates, Taxes, and Insurance				94	11	0			
				302	10	10			
Less Admission to Tank Room				119	10	9	183	0	1
,, Laboratory, Boats, and Sundry Expenses—									
Glass, Apparatus, and Chemicals				173	4	2			
Purchase of Specimens				61	7	7			
Maintenance and Renewal of Boats, Nets, etc.				234	17	1			
Insurance of s.y. *Oithona*, *less* rebate				9	14	0			
Coal and Water for Steamer				111	11	6			
Stationery, Office Expenses, Carriage, Printing, etc.				153	13	1			
				744	7	5			
Less Sales of Apparatus	77	2	8						
,, Specimens	460	10	6						
,, Nets, Gear	137	0	4						
Hire of Boat and Gear	50	13	0	725	6	6	19	0	11
,, Loss on failure of Naval Bank							29	17	3
,, Balance :—									
Cash at Bankers				720	14	3			
Cash in hand				13	10	11	734	5	2
							£2,983	5	1

Examined and found correct,
21st January, 1915.

(Signed) N. E. Waterhouse.
J. O. Borley.
Edward T. Browne.
P. Chalmers Mitchell.

Marine Biological Association of the United Kingdom.

LIST
OF
Governors, Founders, and Members.

1st May, 1915.

* Member of Council. † Vice-President. ‡ President.

Ann. signifies that the Member is liable to an Annual Subscription of One Guinea.

C. signifies that he has paid a Composition Fee of Fifteen Guineas in lieu of Annual Subscription.

I.—Governors.

The British Association for the Advancement of Science, *Burlington House, W.*	£500
The University of Oxford	£500
The University of Cambridge	£500
The Worshipful Company of Clothworkers, 41, *Mincing Lane, E.C.*	£500
The Worshipful Company of Fishmongers, *London Bridge, E.C.*	£11,305
Bayly, Robert (the late)	£1000
Bayly, John (the late)	£600
Thomasson, J. P. (the late)	£970
G. P. Bidder, Esq., *Cavendish Corner, Cambridge*	£1500

II.—Founders.

1884	The Corporation of the City of London	£210
1884	The Worshipful Company of Mercers, *Mercers' Hall, Cheapside*	£341 5*s.*
1884	The Worshipful Company of Goldsmiths, *Goldsmiths' Hall, E.C.*	£100
1884	The Royal Microscopical Society, 20, *Hanover Square, W.*	£100
1884	The Royal Society, *Burlington House, Piccadilly, W.*	£350
1884	The Zoological Society, *Regent's Park, London, N.W.*	£100
1884	Bulteel, Thos. (the late)	£100
1884	Burdett-Coutts, W. L. A. Bartlett, 1, *Stratton Street, Piccadilly, W.*	£100
1884	Crisp, Sir Frank, Bart., Treas. Linn. Soc., 17, *Throgmorton Avenue, E.C.*	£100
1884	Daubeny, Captain Giles A.	£100
1884	Eddy, J. Ray, *The Grange, Carleton, Skipton*	£100
1884	Gassiott, John P. (the late)	£100
‡1884	Lankester, Sir E. Ray, K.C.B., F.R.S., 29, *Thurloe Place, South Kensington, S.W.*	£100

1884	The Rt. Hon. Lord Masham (the late)	£100
1884	Moseley, Prof. H. N., F.R.S. (the late)	£100
1884	The Rt. Hon. Lord Avebury, F.R.S. (the late)	£100
1884	Poulton, Prof. Edward B., M.A., F.R.S., *Wykeham House, Oxford*	£100
1884	Romanes, G. J., LL.D., F.R.S. (the late)	£100
1884	Worthington, James (the late)	£100
1885	Derby, the late Earl of	£100
1887	Weldon, Prof. W. F. R., F.R.S. (the late)	£100
1888	Bury, Henry, M.A., *Mayfield House, Farnham, Surrey*	£100
1888	The Worshipful Company of Drapers, *Drapers' Hall, E.C.*	£315
1889	The Worshipful Company of Grocers, *Poultry, E.C.*	£120
1889	Thompson, Sir Henry, Bart. (the late)	£110
1889	Revelstoke, The late Lord	£100
1890	Riches, T. H., B.A., *Kitwells, Shenley, Herts*	£230
1902	Gurney, Robert, *Ingham Old Hall, Stalham, Norfolk*	£105
1909	Harding, Colonel W., *The Hall, Madingley, Cambridge*	£100
1910	Murray, Sir John, K.C.B., F.R.S. (the late)	£100
1912	Swithinbank, H., F.R.S.E., F.R.G.S., *Denham Court, Denham, Bucks.*	£100
1913	Shearer, Dr. Cresswell, 30, *Thompson's Lane, Cambridge*	£100

III.—Members.

1913	Adams, Alfred, M.B., B.Ch., Oxon., *Looe, Cornwall*	Ann.
1897	Adams, W. R., 11, *Windsor Road, Denmark Hill, Camberwell, London, S.E.*	Ann.
1900	Aders, Dr. W. M., *Zanzibar, East Africa*	Ann.
*1895	Allen, E. J., D.Sc., F.R.S., *The Laboratory, Plymouth*	Ann.
1889	Alward, G. L., *Enfield Villa, Humberstone Avenue, Waltham, Grimsby*	Ann.
1910	Ashworth, J. H., D.Sc., *The University, Edinburgh*	Ann.
1892	Assheton, R., M.A., F.R.S., *Riversdale, Grantchester, Cambridge*	£20
†1911	Astor, W., M.P., 4, *St. James's Square, London, W.*	*C.*
1910	Atkinson, G. T., 43, *Parliament Street, London, S.W.*	Ann.

1902	Baker, R. J., 13, *Brandreth Road, Mannamead, Plymouth*	Ann.
1884	Balfour, Prof. Bayley, F.R.S., *Royal Botanic Gardens, Edinburgh*	*C.*
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1884	Bayly, Miss, *Seven Trees, Plymouth*	£50
1884	Bayly, Miss Anna, *Seven Trees, Plymouth*	£50
1885	Beck, Conrad, 68, *Cornhill, E.C.*	*C.*
1884	Beddington, Alfred H., 8, *Cornwall Terrace, Regent's Park, N.W.*	*C.*
†1907	Bedford, His Grace the Duke of, K.G., *Endsleigh, Tavistock*	*C.* & Ann. £10 10s.
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1910	Bloomer, H. H., 40, *Bennett's Hill, Birmingham*	Ann.
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*1884	Bourne, Prof. Gilbert C., M.A., F.R.S., *Savile House, Mansfield Road, Oxford*	Ann.
1910	Bowkett, Sidney	Ann.

1898	Bowles, Col. Henry, *Forty Hall, Enfield*	Ann
1910	Bradford, Sir J. Rose, K.C.M.G., M.D., D.Sc., F.R.S., 8, *Manchester Square, London, W.*	Ann.
1902	Brighton Public Library (Henry D. Roberts, Chief Librarian)	Ann.
1886	Brooksbank, Mrs. M., *Leigh Place, Godstone, Surrey*	*C.*
1884	Brown, Arthur W. W., 62, *Carlisle Mansions, Carlisle Place, London, S.W.*	*C.*
*1893	Browne, Edward T., B.A., *Anglefield, Berkhamsted*	Ann.
1892	Browne, Mrs. E. T., *Anglefield, Berkhamsted*	Ann.
*1897	Byrne, L. W., B.A., 7, *New Square, Lincoln's Inn, London, W.C.*	Ann.
1908	Calman, Dr. W. T., *British Museum (Natural History), Cromwell Road, S.W.*	Ann.
1912	Cavers, Dr. F., *Goldsmiths' College, New Cross, London, S.E.*	Ann.
1913	Childs, Christopher, M.D., *Boscarne, Looe*	Ann.
1911	Chilton, Prof. C., *Canterbury College, Christchurch, New Zealand*	Ann.
1884	Christy, Thomas Howard	*C.*
1911	Clark, Dr. J., *Technical School, Kilmarnock, N.B.*	Ann.
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1885	Darwin, W. E., *Ridgemount Bassett, Southampton*	£20
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1908	Dendy, Prof. A., F.R.S., *Vale Lodge, Hampstead Heath, N.W.*	Ann.
1910	Devonport Education Authority	Ann.
1884	Dewick, Rev. E. S., M.A., F.G.S., 26, *Oxford Square, Hyde Park, W.*	*C.*
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1910	Dobell, C. C., M.A., *Imperial College of Science and Technology, South Kensington, S.W.*	Ann.
1890	Driesch, Hans, Ph.D., *Philosophenweg* 5, *Heidelberg, Germany*	*C.*
†1889	Ducie, The Rt. Hon. the Earl of, F.R.S., *Tortworth Court, Falfield, R.S.O.*	£50 15*s.*
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1884	Dyer, Sir W. T. Thiselton, M.A., K.C.M.G., F.R.S., *The Ferns, Witcombe, Gloucester*	*C.*
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1906	Gardiner, Prof. J. Stanley, M.A., F.R.S., *Caius College, Cambridge*	Ann.
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1901	Giles, Col. G. M.	*C.*
1910	Gooding, H. C., *Ipswich Street, Stowmarket*	Ann.
*1910	Goodrich, E. S., F.R.S., *Merton College, Oxford*	Ann.
1885	Gordon, Rev. J. M., 7, *Moreton Gardens, London, S.W.*	Ann.
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1910	Hefford, A. E., B.Sc., 43, *Parliament Street, London, S.W.*	Ann.
1908	Hepworth, Commander M. W. Campbell, C.B., R.N.R., *Meteorological Office, South Kensington, London, S.W.*	Ann.
*1884	Herdman, Prof. W. A., F.R.S., *The Zoology Department, The University, Liverpool*	Ann.
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*1907	Hill, Prof. J. P., F.R.S., *The Zoological Laboratory, University College, London, W.C.*	Ann.
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1912 Matthews, Mrs. D. J., *The Laboratory, Plymouth* ... Ann.
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1906 Morford, Rev. Augustin, *The Friary, Saltash, Cornwall* ... Ann.
*1915 Morley, C. C., c/o Messrs. Morley, Sellick and Price, Steam Trawler Owners, *Milford Haven* ... Ann.
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1912 Newman, C. A., *Bramston House, Oundle* ... Ann.
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1911 Oldham, Chas., *Kelvin, Boxwell Road, Berkhamsted, Herts.* ... Ann.
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1910	Pennell, Commander H., *Awliscombe, Honiton, Devon*	Ann.
1906	Plymouth Corporation (Museum Committee)	Ann.
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1906	Port of Plymouth Incorporated Chamber of Commerce	Ann.
1910	Porter, Horatio, 16, *Russell Square, London, W.C.*	Ann.
*1913	Potts, F. A., M.A., *Trinity Hall, Cambridge*	C.
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1893	Quintin, St. W. H., *Scampstone Hall, Rillington, Yorks*	Ann.
1913	Raymond, Major G., *The Gymnasium, Western College Road, Plymouth*	Ann.
1914	Samuel, T. A. S., *North Hill House, Torpoint, Cornwall*	Ann.
1911	Saunders, J. T., B.A., *Christ's College, Cambridge*	Ann.
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1888	Serpell, E. W., *Loughtonhurst, West Cliff Gardens, Bournemouth*	£50
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1904	Shaw, Joseph, K.C., *Bryanston Square, London, W.*	£13
1885	Sheldon, Miss Lilian, *High Park, Bideford*	Ann.
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1884	Skinners, the Worshipful Company of, *Skinners' Hall, E.C.*	£42
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*1910	Smith, Geoffrey W., *New College, Oxford*	Ann.
1888	Spencer, Prof. W. Baldwin, M.A., F.R.S., *University of Victoria, Melbourne*	Ann.
1907	Sprague, Thomas Bond, M.A., LL.D., 29, *Buckingham Terrace, Edinburgh*	Ann.
1897	Straker, J., LL.M., F.Z.S., *Oxford and Cambridge Club, S.W.*	C.
*1899	Thompson, Prof. D'Arcy W., C.B., *University College, Dundee*	Ann.
1890	Thompson, Sir H. F., Bart., 9, *Kensington Park Gardens, London, W.*	Ann.
1884	Thornycroft, Sir John I., F.R.S., *Eyot Villa, Chiswick Mall*	Ann.
1906	Tims, H. W. Marett, M.D., *Bedford College, Regent's Park, London, N.W.*	Ann.
1903	Torquay Natural History Society, *Torquay*	Ann.
*1897	Travers, J. A., *Tortington House, Arundel*	C.
1910	Travers, Miss R. C., *Tortington House, Arundel*	C.
1891	Vaughan, Henry	C.
1884	Walker, Alfred O., *Ulcombe Place, Maidstone*	Ann.
1884	Walker, P. F., 36, *Prince's Gardens, S.W.*	Ann.
1910	Wallace, W., D.Sc., 43, *Parliament Street, London, S.W.*	Ann.
†1884	Walsingham, The Rt. Hon. Lord, F.R.S., *Merton Hall, Thetford*	£20
1912	Ward, Dr. Francis, 20, *Park Road Ipswich*	Ann.

1906 Waterhouse, N. E., 3, *Fredericks Place, Old Jewry, London, E.C.* ...... Ann.
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1893 Worth, R. H., 42, *George Street, Plymouth* .... Ann.

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1889 Olsen, O. T., F.L.S., F.R.G.S., *Fish Dock Road, Great Grimsby.*
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1901 Sanders, W. J., *Rockvall, Brixham.*
1889 Sinel, Joseph, 8, *Springfield Cottages, Springfield Road, Jersey, C.I.*
1890 Wells, W., *The Aquarium, Brighton.*

INDEX.

A

Abstracts of Memoirs recording work done at the Plymouth Laboratory, 513
Acanthochasmus imbutiformis, 472, 488, 497, 503
Acanthocites fascicularis, 108
Acanthodoris pilosa, 110
Acartia, experiments in keeping, 561, 566
Acholoë astericola, 613
Acmaea virginea, 109
Actinia equina, 106
Actiniae, Comparative Anatomy of some British, 521
Æolidia papillosa, 110
Æolidiella angulata, 110
— *glauca*, 110
Agonus cataphractus, host of Derogenes, 487
Ahnfeldtia plicata, 105
Alcyonidium hirsutum, 108
Alcyonium ficus, synonymy of, 264
— *pulmonis instar lobatum*, 262
Algae of Cardigan Bay, 105
Allen, E. J., On the Culture of the Plankton Diatom *Thalassiosira gravida* Cleve, in Artificial Sea-water, 417
— Polychaeta of Plymouth and the South Devon Coast, including a list of the Archiannelida, 592
Amathia lendigera, 108
Amathilla homari, 111
Amblyosyllis lineata, 603
Ammodytes lanceolatus, 340; host of *Hemiurus*, 484
— *tobianus*, 340, 467
Ammotrypane aulogaster, 638
Amphicteis curvipalea, 637
— *Gunneri*, 637
Amphiglena mediterranea, 643
Amphioxus, ciliary mechanisms on the gill of, 22, 297; mode of feeding in, 20, 35, 298; hermaphrodite specimen of, 506; experiments in rearing, 510
Amphiporus lactifloreus, 107
Amphitrite Edwardsi, 633
— *gracilis*, 633
— *Johnstoni*, 633
Amphiura, 107
Ancula cristata, 110
Anemones, Some Plymouth, 60
Anemonia sulcata, 106
Anguilla vulgaris, host of *Podocotyle*, 473, *Helicometra*, 476, *Lecithochirium*, 485
Annelida, rate of growth in, 316
Anodonta cygnea, 323
Anomalocera Patersoni, experiments in keeping, 561
Anomia aculeata, rate of growth, 320
— *ephippium*, 110
Antenella secundaria, 260
— *siliquosa*, 261
Antennularia antennina, 440, 445
— *ramosa*, 440, 445
Anthopleura alfordi, 536
Anthura gracilis, 236
Aonides oxycephala, 629
Aphroceras (Leucandra) cliarensis, found near Plymouth, 258
Aphrodite aculeata, 608
Aphya pellucida, 372
Arabella (Maclovia) iricolor, 623
Archiannelida of Plymouth, 595

Archidoris tuberculata, 110
Arenicola branchialis, 640
— *ecaudata*, 640
— *Grubei*, 640
— *marina*, 108, 639
Aricia Cuvieri, 627
— *Latreilli*, 627
Arnoglossus imperialis, 356
— *laterna*, 356
— *thori*, 356
Artificial sea-water, 421, 434
Ascidia conchilega, 324
Ascidians, ciliary mechanisms of, 33, 287 ; mode of feeding in, 30, 35
Ascidiella aspersa, life history, 324
Ascophyllum nodosum, 105
Asperococcus echinatus, 105
Asterias glacialis, development of, 2 ; experiments with, 56 ; larva of, 4
— *rubens*, larva of, 4 ; in Cardigan Bay, 107
— *vulgaris*, larva of, 4
Athanas nitescens, 112
Atherina presbyter, host of *Podocotyle*, 474 ; of *Bacciger*, 481
Aulactinia gelam, 536
Aureliania regalis, 550
Autolytus Edwarsi, 605
— *ehbiensis*, 605
— *inermis*, 606
— *longiferiens*, 604
— *lugens*, 606
— *macrophthalma*, 604
— *pictus*, 604
— *prolifer*, 605
— *punctatus*, 605
— *rubropunctatus*, 604
Axine belones, 472, 496, 502
Axius stirhynchus, 112

B

Bacciger bacciger, 470, 481, 500
Bacteria, influence of, in plankton experiments, 572
Balance Sheet, **1912**, 134 ; **1913**, 414 ; **1914**, 654
Balanoglossus, ciliation of the gill of, 37
Balanus balanoides, 111, 257 ; rate of growth, 317
— *perforatus*, 111
Bangia fuscopurpurea, 105
Belone vulgaris, host of *Axine*, 496
Bipinnaria laevis, 5
— *Russoi*, 2
Bispira volutacornis, 642
Blennius gattorugine, 113 ; host of *Helicometra*, 476, *Zoogonoides*, 483, *Monorchis*, 484
— *ocellaris*, 379 ; host of *Steringotrema*, 480, *Zoogonoides*, 483, *Derogenes*, 487
— *pholis*, 113, 379 ; host of *Peracreadium*, 476, *Helicometra*, 476, *Lecithochirium*, 485
Bothus maximus, host of *Derogenes*, 487
Botrylloides sp., 112
Botryllus violaceus, 112 ; rate of growth, 325
Bougainvillea ramosa, 313
Bouvier, E. L. Recherches sur le Développement post-embryonnaire de la Langouste commune (Palinurus vulgaris), 179
— Observations nouvelles sur les *trachelifer*, larves luciferiformes de *Jaxea nocturna*, 194
— Quelques mots sur la variabilité du *Pycnogonum littorale*, Ström., 207
Bowerbankia imbricata, 108
— *sp.*, rate of growth in, 317
Brachiopods, ciliary mechanisms in, 283 ; mode of feeding, 294
Branchiomma vesiculosum, 641
Bryopsis plumosa, 105
Bucephalopsis gracilescens, 472, 491
Bucephalus minimus, 472, 492, 497
— *polymorphus*, 489
Bugula flabellata, rate of growth in, 316
Bunodera nodulosa, 471, 487, 502

C

Caesicirrus neglectus, 639
Cainocreadium labracis, 469, 476, 497
Calanus finmarchicus, experiments in keeping, 556, 559, 562, 565
Calicotyle kroyeri, 473, 497, 503
Calliobdella lophii, 81

Callionymus lyra, 378 ; host of *Lebouria*, 475, *Zoogonoides*, 483, *Derogenes*, 487
Calliopius laeviusculus, 111
Calliostoma zizyphinus, 109, 114, 115
Callithamnion hookeri, 105
Calyptraea, endostyle of, 303
Cancer pagurus, 112
Canthocamptus palustris, 111
Capitella capitata, 639
Caprella linearis, 111
Capros aper, 353 ; host of *Pharyngora*, 478, *Hemiurus*, 484, 485, *Derogenes*, 487
Caranx trachurus, 348
Carcinus maenas, 112 ; rate of growth, 318
Cardigan Bay, Fauna of, 102
Cardium edule, 111 ; rate of growth, 323
Castagnea griffithsiana, 105
— *virescens*, 105
Castalia fusca, 107, 607
— *punctata*, 607
Catanella spuntia, 105
Cellularia neritina, rate of growth in, 317
Centrolabrus exoletus, host of *Lebouria*, 475
Centronotus gunnellus, 113, 467 ; host of *Podocotyle*, 473
Ceramium acanthonotum, 105
— *ciliatum*, 105
— *diaphanum*, 105
— *rubrum*, var. *proliferum*, 105
— *strictum*, var. *divaricata*, 105
Ceratium arcticum, distribution of, 519
— *longipes*, distribution of, 519
Chaetomorpha melagonium, 105
— *tortuosa*, 105
Chaetopterus, rate of growth in, 316 ; tubes containing Crystallogobius eggs, 373
Chaetopterus variopedatus, 631
Chantransia virgatula, 105
Chondrus crispus, 105
Chorda filum, 105
Chlorodendron subsalsum, as food for Plankton animals, 558, 574
Chordaria flagelliformis, 105
Chthamalus stellatus, 111
Ciliary mechanisms, 19, 283
Ciona intestinalis, life history, 324
Cirratulus (Audouinia) tentaculatus, 632
— *cirratus*, 108, 632
— *norvegicus*, 632
Cladophora albida, 105
— *pellucida*, 105
— *sericea*, 105
Cladostephus spongiosus, 105
— *verticillatus*, 105
Clark, R. S. General Report on the Larval and Post-Larval Teleosteans in Plymouth Waters, 327
Clavellina lepadiformis, 324
Clupea pilchardus, host of *Hemiurus*, 485
— *sprattus*, 467
Clupeidae, larval and post-larval, 338
Clytia Johnstoni, 313
Coelenterata, of Cardigan Bay, 106 ; rate of growth, 313
Colochirus lacazei, 226, 229
Conchidium Knighti, 295
Conchoderma aurita, rate of growth, 317
— *virgata*, rate of growth, 317
Conger conger, host of *Helicometra*, 476, *Lecithochirium*, 485, *Derogenes*, 487, *Prosorhynchus*, 494
Corallina officinalis, 105
Corynactis albida, 550
— *annulata*, 550
— *australis*, 544, 550
— *cornea*, 544, 548
— *globulifera*, 550
— *gracilis*, 550
— *Haddoni*, 550
— *Hertwigi*, 550
— *hoplites*, 545, 548
— *mollis*, 550
— *myrcia*, 545, 548
— *viridis*, 543, 548
Coryne vaginata, 106
Cottus bubalis, 113, 375 ; host of *Podocotyle*, 473, *Hermiurus*, 484, *Derogenes*, 487, *Prosorhynchus*, 494
Crangon vulgaris, 111
Crania, mode of feeding in, 284
Crawshay, L. R. Report on the Distribution of the Microplankton [Abstract], 518

Crawshay, L. R. Notes on Experiments in the Keeping of Plankton Animals under Artificial Conditions, 555
— A Method of Separating Sponge Spicules by Filtration, 590
Crenilabrus melops, 113; host of *Lebouria*, 475, *Peracreadium*, 475, *Synaptobothrium*, 486
— *rupestris*, 113
Crepidula, endostyle of, 303; rate of growth, 320, 323; age of sex-change, 322
Crisia cornuta, 108
— *denticulata*, 108
Crustacea, rate of growth in, 317
Crystallogobius nilssoni, 372
Ctenodrilus pardalis, 596
Ctenolabrus rupestris, 347, 392; host of *Lebouria*, 475, *Helicometra*, 476
Cucumaria elongata, 227, 229
— *frondosa*, 223
— *hyndmanni*, 223
— *lefevrei*, 226
— *montagui*, 222, 225
— *normani*, specific characters, 211; synonymy of, 223, 225
— *pentactes*, 223, 231
— *planci*, 223
— *saxicola*, specific characters of, 211; synonymy of, 223, 225
Cyathura carinata, 239
Cyclogaster montagui, 376; host of *Podocotyle atomon*, 473
Cyclopterus lumpus, 113, 376; host of *Pharyngora*, 478, *Derogenes*, 487

D

Dasychone, growth rate in, 316
Dasychone bombyx, 642
De Morgan, W., and Drew, G. H. A Study of the Restitution Masses formed by the Dissociated Cells of the Hydroids *Antennularia ramosa* and *A. antennina*, 440
Dendy, A. On the Occurrence of *Aphroceras* (*Leucandra*) *cliarensis* Stephens near Plymouth, 258
Derogenes varicus, 471, 487, 497, 498, 499, 501, 502, 503
Derogenoides ovacutus, 471, 487, 498
Desmarestia aculeata, 105
Dexamine spinosa, 111
Diatom cultures in artificial sea-water, 417, 425, 570
Dictyosiphon foeniculaceus, 105
Dictyota dichotoma, 105
Dinophilus gyrociliatus, 595
— *taeniatus*, at Cardigan Bay, 107; rate of growth, 316; at Plymouth, 595
Dodecaceria concharum, 632
Donax vittatus, 111
Doto coronata, 110, 323
Dromia vulgaris, 112

E

Echinodermata of Cardigan Bay, 106
Echinoderms, Development of, 1
Echinus acutus, experiments with, 55, 57, 256, 464
— *esculentus*, experiments with, 56; 256, 464
— *miliaris*, experiments with, 55, 57, 465; breeding habits, 254
Ectocarpus confervoides, var. *siliculosa*, 105
— *tomentosus*, 105
Edwardsia claparedi, 61
— *timida*, 60
Elachista fucicola, 105
Eloactis mazeli, 68, 70
Enteromorpha compressa, 105
— *intestinalis*, 105
— *linza*, 105
Ephesia gracilis, 625
— *peripatus*, 626
Eteone picta, 616
— *pusilla*, 618
Eulalia aurea, 615
— *bilineata*, 615
— *Claparedii*, 616
— (*Eumida*) *sanguinea*, 616
— *nebulosa*, 616
— *obtecta*, 614
— *ornata*, 615
— *pallida*, 616

Eulalia (*Pterocirrus*) *macroceros*, 616
— *punctifera*, 616
— *tripunctata*, 616
— *viridis*, 107, 615
Eunice fasciata, 624
— *Harasii*, 624
— *vittata*, 624
Eunoa nodosa, 609
Eupagurus bernhardus, 112
Euphrosyne foliosa, 608
Euplotes, action on Bacteria, 573
Eurysyllis paradoxa, 600
Eusyllis lamelligera, 599
— *monilicornis*, 599
— *tubifex*, 599
Evaluation of the Sea, 312
Evarne impar, 611
Exogone gemmifera, 597
Experiments in the keeping of Plankton animals, 555

F

Fabricia sabella, 643
Facelina coronata, 110
— *drummondi*, 110, 323
Fauna of Cardigan Bay, 102
Filograna, rate of growth in, 316
Filograna implexa, 644
Fishes, trematode parasites of, 466; list of species examined, 497
Fissurella graeca, 109
Flabelligera (*Siphonostoma*), *affinis*, 641
Fovia affinis, 107
Fuchs, H. M. On F_2 *Echinus* Hybrids, 464
Fucus cerenoides, 105
— *serratus*, 105
— *vesiculosus*, 105
Furcellaria fastigiata, 105

G

Gadus luscus, 340; host of *Stephanochasmus*, 477, *Hemiurus*, 484, *Derogenes*, 487
— *merlangus*, 340; host of *Podocotyle*, 473, *Pharyngora*, 478, *Hemiurus*, 484, 485, *Lecithaster*, 486, *Derogenes*, 487, *Acanthochasmus*, 488, *Octobothrium*, 496
Gadus minutus, 340; host of *Stephanochasmus*, 477, *Hemiurus*, 484, *Derogenes*, 487
— *pollachius*, host of *Lepidapedon*, 478, *Hemiurus*, 484, 485, *Derogenes*, 487
Galathea intermedia, 89
— *nexa*, 89
— *squamifera*, 84, 85, 88, 112
— *strigosa*, 89
Galatheidea, habit and habitat in the, 84
Galvina exigua, 323
— *farrani*, 323
— *picta*, life history, 323
Gammarus locusta, 111
— *pulex*, 111
Gasterosteus spinachia, 113
Gasterostomata, 488; synonymy, 489
Gasterostomum fimbriatum, 489
— *gracilescens*, 489
— *minimum*, 489, 492
— *tergestinum*, 489
— *triglae*, 489, 492
— *viperae*, 489
Gastraea spinachia, host of *Podocotyle*, 473
Gattyana cirrosa, 609
Gemmill, J. F. Twin Gastrulae and Bipinnariae of *Luidia sarsi*, Düben and Koren, 577
Gibbula cineraria, 109, 114, 115
— *magus*, 109, 114, 116
— *umbilicata*, 109, 114, 115
Gigartina teedii, 105
Glycera alba, 626
— *capitata*, 626
— *convoluta*, 626, 627
— *gigantea*, 626
— *Goësi*, 627
— *lapidum*, 626
— *Mesnili*, 627
— *Rouxii*, 627
Gnathia edwardii, 111
Gobius microps, 372
— *minutus*, 372
— *paganellus*, host of *Helicometra*, 476, of *Hemiurus*, 484
— *ruthensparri*, host of *Podocotyle*, 473
— *scorpioides*, 372

Goniada maculata, 626
Goniodoris castanea, 110
— *nodosa*, 110
Grantia compressa, rate of growth, 314
Gray, J. The Electrical Conductivity of Fertilized and Unfertilized Eggs, 50
Grubea clavata, 598
— *limbata*, 598
— *pusilla*, 598
Gunda ulvae, regeneration in, 513, 514
Gyptis propinqua, 607

H

Halcampa arenaria, 66
— *chrysanthellum*, 65
Halichondria panicea, 106, 315
Halidrys siliquosa, 105
Halisarca dujardini, 106
Halosydna gelatinosa, 612
Haplobranchus aestuarius, 643
Haploporus benedeni, 470, 484, 500
Harmothoë areolata, 611
— *fraser-thomsoni*, 611
— *imbricata*, 107, 610
— *lunulata*, 610
— *marphysae*, 611
— *setosissima*, 611
— *spinifera*, 610
Hartmeyer, R. On *Alcyonium pulmonis instar lobatum*, 262
Helcion pellucida, 108
Helicometra pulchella, 469, 476, 497, 499, 500, 501, 502, 503
Hemimysis lamornae, used in diatom cultures, 429
Hemipera ovocaudata, 471, 487, 500
Hemiurus communis, 471, 484, 497, 498, 499, 500, 501, 502, 503
— *ocreatus*, 471, 485, 498, 501, 502
Henricia sanguinolenta, 107
Hermaphrodite specimen of Amphioxus, 506
Hermione hystrix, 608
Heterocirrus caput-esocis, 633
— *viridis*, 633
Heteroclymene robusta, 639
Heteromastus filiformis, 639
Hildenbrandtia prototypus, var. *rosea*, 105
Hippolyte varians, 112
Histriobdella homari, 596
Holothuria montagui, 226
— *nigra*, development of, 17
— *pentactes*, 226
Homarus vulgaris, 112
Hyalinoecia sicula, 624
— *tubicola*, 624
Hydrographical Observations in the Labrador Current in 1913, 515
Hydroides norvegica, rate of growth, 316; at Plymouth, 644
Hydroids, dissociated cells in, 440
Hymeniacidon sanguineum, 106

I

Idotea baltica, 111
— *marina*, 111

J

Jaera marina, 111
Jasmeneira elegans, 643
Jaxea nocturna, 194
Jorunna johnstoni, 110

K

Kefersteinia cirrata, 607

L

Labrax lupus, host of *Cainocreadium*, 476, *Acanthochasmus*, 488, *Bucephalus*, 492
Labrus bergylta, 347; host of *Lebouria*, 475, of *Peracreadium*, 475, of *Helicometra*, 476, of *Lepidauchen*, 478, *Synaptobothrium*, 486
— *mixtus*, 347; host of *Helicometra*, 476
Lacuna divaricata, 109
— *puteolus*, 109
Lagisca elisabethae, 610
— *extenuata*, 609
— *floccosa*, 107, 609
— *propinqua*, 609
— *rarispina*, 610
Lamellibranchs, function of the gill in, 44

Lamellidoris bilamellata, 110
Laminaria digitata, 105
— *saccharina*, 105
Langouste, développement post-embryonnaire de la, 179
Lanice conchilega, 108, 634
Larval and Post-Larval Teleosteans in Plymouth waters, 327
Laurencia hybrida, 105
Leander serratus, 111
Leathesia difformis, 105
Lebouria alacris, 469, 475, 500, 501
— *varia*, 469, 475, 499
Lecithaster gibbosus, 471, 486, 497, 498, 499, 501, 502
Lecithochirium rufoviride, 471, 485, 498, 500, 502, 503
Lecithocladium excisum, 471, 485, 498
Leigh-Sharpe, W. H. *Calliobdella lophii*, Van Beneden and Hesse, 81
Leonnates pusillus, 244, 249, 251
Lepadogaster bimaculatus, 378
— *candollei*, 378
— *decandolii*, 113
— *gouani*, 378, 467 ; host of *Helicometra*, 476, *Hemiurus*, 484, *Hemipera*, 487
Lepas anatifera, rate of growth, 317
— *hilli*, rate of growth, 317
Lepidapedon rachion, 470, 478, 501
Lepidasthenia argus, 613, 633
Lepidauchen stenostoma, 470, 478, 500
Lepidonotus clava, 608
— *squamatus*, 608
Lepralia pallasiana, rate of growth in, 317
Leptonereis, 244
— *cebuensis*, 249, 250
— *glauca*, 244, 618
— *laevis*, 250
— *pusillus*, 251
— *vaillanti*, 245, 248, 619
Leptoplana tremellaris, 107
Leptoclinum (*Diplosoma*) *gelatinosum*, life history, 324
Leucosolenia, rate of growth, 314
Ligia oceanica, 111
Lineus longissimus, 107
Lingula, 285, 295
Liparis montagui, 113
Liparis vulgaris, 113
List of Governors, Founders, and Members, 1913, 136 ; 1915, 656
Lithothamnion polymorphum, 105
Littorina littorea, 109, 115, 117, 120
— *neritoides*, 109, 115, 116
— *obtusata*, 109, 115, 116, 120
— *rudis*, 109, 115, 116, 120
Littorinidae in Cardigan Bay, 114
Lloyd, D. J. The Influence of the Position of the Cut upon Regeneration in *Gunda ulvae* [Abstract], 513
— The Influence of Osmotic Pressure upon the Regeneration of *Gunda ulvae* [Abstract], 514
Loimia medusa, 636
Lomentaria articulata, 105
Lophius piscatorius, host of *Calliobdella*, 81, *Hemiurus*, 484, *Lecithochirium*, 485, *Synaptobothrium*, 486, *Derogenes*, 487, *Bucephalopsis*, 491
Luidia ciliaris, development of, 6
— *sarsi*, 8 ; twin gastrulae and bipinnariae of, 577
Lumbriconereis fragilis, 623
— *impatiens*, 623
— *Latreilli*, 623
Lysidice ninetta, 625
— *punctata*, 625
— sp., 107

M

Macoma balthica, 111, 121
Macroclinum pomum, 263 ; bibliography, 272 ; distribution, 276
Magalia perarmata, 607
Magelona papillicornis, 631
Malmgrenia castanea, 612
Marphysa Belli, 625
— *sanguinea*, 625
Matthews, D. J. Hydrographical Observations in the Labrador Current in 1913. [Abstract], 515
Melinna adriatica, 636
Members, list of, 136
Membranipora membranacea, 108 ; rate of growth, 317
— *pilosa*, 108
Mesogloea vermiculata, 105
Microcotyle draconis, 472, 497, 498

Micromaldane ornithochaeta, 639
Micronereis variegata, 618
Microplankton in the North Atlantic, 518
Molgula ampulloides, 324
Mollusca, of Cardigan Bay, 108 ; ciliary mechanisms on the gills, 283 ; rate of growth, 318
Molva molva, 344 ; host of *Hemiurus*, 484, *Derogenes*, 487
Monodonta crassa, 109, 114, 115, 117
Monorchis monorchis, 470, 484, 499
Mortensen, Th. On the Development of some British Echinoderms, 1
Mugil chelo, host of *Saccocoelium* and *Haploporus*, 484
Mullus barbatus, host of *Derogenes*, 487
— *surmuletus*, 346
Munida rugosa, 85
Mustelus vulgaris, host of *Ptychogonimus*, 484
Myrianida pinnigera, 606
Myriotrichia clavaeformis, var. *filiformis*, 105
Mystides limbata, 618
Mytilus edulis, 110 ; rate of growth, 318, 323
Myxicola infundibulum, 642
— (*Leptochone*) *aesthetica*, 642

N

Nassa reticulata, 110
Nauplii, experiments in keeping, 561, 564
Nematonereis unicornis, 625
Nemertini of Cardigan Bay, 107
Nephthys caeca, 621
— *cirrosa*, 622
— *Hombergi*, 621
Nereis dumerilii, 246
— *eugeniae*, 251
— *fimbriata*, 619
— *irrorata*, 620
— *loxechini*, 251
— *pelagica*, 107, 245, 619
— *procera*, 619
— *zonata*, 619
— (*Eunereis*) *longissima*, 620
— (*Hediste*) *diversicolor*, 620
Nereis (*Leptonereis*) *glauca*, 250
— (*Nereilepas*) *fucata*, 621
— (*Perinereis*) *cultrifera*, 619
— — *Marioni*, 619
— (*Platynereis*) *Dumerilii*, 620
— (*Praxithea*) *Schmardaei*, 620
Nerilla antennata, 596
Nerine cirratulus, 628
— *coniocephala*, 628
— *foliosa*, 628
— *vulgaris*, 629
Nerophis aequoreus, 340 ; host of *Podocotyle*, 473, *Hemiurus*, 485
— *lumbriciformis*, 113
Nicolea venustula, 635
— *zostericola*, 635
Nicoll, W. The Trematode Parasites of Fishes from the English Channel, 466
Nicomache lumbricalis, 639
Nicon loxechini, 251
Nitzschia closterium, as food for Plankton animals, 558
Notomastus latericeus, 637
— *rubicundus*, 637
Notophyllum foliosum, 614
Nucula, ciliation of the gill in, 43
Nymphon gracile, 112

O

Obelia dichotoma, 106
— *geniculata*, 106, 323
Octobothrium merlangi, 472, 496, 501
Octocotyle scombri, 472, 496, 498
Odontosyllis ctenostoma, 599
— *fulgurans*, 599
— *gibba*, 599
Onos cimbrius, 345
— *mustela*, 345 ; host of *Podocotyle*, 473
— (*Motella*) *mustelus*, 113
— — *tricirratus*, 113
— *tricirratus*, 345 ; host of *Derogenes*, 487
Onuphis britannica, 624
— *conchilega*, 624
Ophelia bicornis, 638
— *limacina*, 638
— *neglecta*, 638
Ophiactis Balli, development of, 11

Ophiocoma nigra, development of, 12
Ophiodromus flexuosus, 607
Ophiothrix fragilis, 13, 107
Ophryotrocha, rate of growth in, 316
Ophryotrocha puerilis, 623
Oria armandi, 643
Orton, J. H. The Ciliary Mechanisms on the Gill and the Mode of Feeding in Amphioxus, Ascidians, and *Solenomya togata*, 19
— On some Plymouth Holothurians, 211
— On the Breeding Habits of *Echinus miliaris*, with a Note on the Feeding Habits of *Patella vulgata*, 254
— On Ciliary Mechanisms in Brachiopods and some Polychaetes, with a Comparison of the Ciliary Mechanisms on the Gills of Molluscs, Protochordata, Brachiopods and Cryptocephalous Polychaetes, and an Account of the Endostyle of Crepidula and its Allies, 283
— Preliminary Account of a Contribution to an Evaluation of the Sea, 312
— On a Hermaphrodite Specimen of Amphioxus, with Notes on Experiments in Rearing Amphioxus, 506
Owenia fusiformis, 632
Oxydromus propinquus, 607
Oyster spat, rate of growth, 323

P

Palaemon serratus, rate of growth, 318
Palinurus vulgaris, development of, 179
Pallasia murata, 645
Paludestrina stagnalis, 110
Patella vulgata, 108; feeding habits, 254, 257; rate of growth, 319, 323
Pectinaria (*Amphictene*) *auricoma*, 637
— (*Lagis*) *Koreni*, 637
— (*Petta*) *pusilla*, 637
Pedicellina cernua, 108
Pelvetia canaliculata, 105
Peracreadium commune, 469, 475, 500
— *genu*, 469, 476, 500
Petromyzon fluviatilis, observations on the Ammocoete of, 38
Pharyngora bacillaris, 470, 478, 498, 499, 501
Phasianella pullus, 109
Pholoë minuta, 614
Phoronis, lophophoral cirri of, 301
Phyllitis fascia, 105
Phyllochaetopterus anglica, 631
Phyllocotyle gurnardi, 499
Phyllodoce lamelligera, 616
— *laminosa*, 617
— *maculata*, 617
— *paretti*, 617
— *rubiginosa*, 617
— *teres*, 617
Phyllophora membranifolia, 105
Pilumnus hirtellus, 112
Pinnotheres pisum, 113
Pionosyllis divaricata, 598
— *hyalina*, 600, 601
— *lamelligera*, 598
— *prolifera*, 600, 602
— (*Typosyllis*) *alternosetosa*, 600
— — *armillaris*, 600
— — *krohnii*, 603
— — *prolifera*, 600
— — *variegata*, 602
Plankton Diatoms, Culture of, 417, 555
Platyhelminthes, rate of growth in, 316
Pleuronectes flesus, 355; host of *Podocotyle*, 473, *Derogenes*, 487
— *limanda*, 355, 467; host of *Steringotrema*, 479, *Zoogonoides*, 483, *Derogenes*, 487
— *microcephalus*, 355; host of *Steringotrema*, 479, *Zoogonoides*, 483
— *platessa*, host of *Zoogonoides*, 483
Plumaria elegans, 105
Plumularia catharina, 260
— *echinulata*, 106
— *pinnata*, 106
— *similis*, 106
Plymouth collecting grounds, 593
Plymouth Holothurians, 211
Podocoryne carnea, 106
Podocotyle atherinae, 469, 474, 500
— *atomon*, 469, 473, 498, 499, 500, 501, 502
— *reflexa*, 469, 473, 500, 501
— *syngnathi*, 469, 473, 503

Poecilochaetus serpens, 631
Polycera lessoni, 110
Polychaeta of Cardigan Bay, 107 ; of Plymouth and S. Devon coast, 592, 597
Polychaetes, ciliary mechanism in, 283, 301
Polycirrus aurantiacus, 636
— *caliendrum*, 636
— *haematodes*, 636
Polydora caeca, 630
— *ciliata*, 630
— *flava*, 630
— *hoplura*, 631
Polygordius lacteus, 596
Polyides rotundus, 105
Polymnia, rate of growth in, 316
Polymnia nebulosa, 634
— *nesidensis*, 634
Polynoe crassipalpa, 612
— *Johnstoni*, 612
— *scolopendrina*, 612
Polyophthalmus pictus, 639
Polysiphonia elongata, 105
— *nigrescens*, 105
— *urceolata*, var. *patens*, 105
— *violacea*, 105
Polyzoa, of Cardigan Bay, 108 ; rate of growth, 316
Pomatoceros triqueter, 108, 644 ; rate of growth, 316
Porcellana longicornis, 90, 112
— *platycheles*, 84, 86, 90
Porifera, of Cardigan Bay, 106 ; rate of growth, 314
Porphyra linearis, 105
Portunus puber, 112 ; rate of growth, 318
Potamilla incerta, 642
— *reniformis*, 642
— *Torelli*, 642
Procerastea halleziana, 606
Prosorhynchus aculeatus, 472, 488, 494, 503
— *crucibulum*, 472, 482, 494, 503
— *squamatus*, 472, 488, 494, 498
— *triglae*, 472, 495, 499
Protodrilus flavocapitatus, 595
— *Leuckartii*, 596
Protula tubularia, 645
Psamathe fusca, 107
Pseudocalanus elongatus, 564
Pseudocotyle squatinae, 473, 497, 503
Pterosyllis formosa, 603
— (*Gattiola*) *spectabilis*, 603
Ptychogonimus megastomus, 471, 484, 503
Publications recording results of researches :—
  Annelids, 166
  Botanical, 177
  Coelenterates, 170
  Crabs and Lobsters, 157
  Crustacea, 163
  Echinoderms, 168
  Faunistic and General Papers, 173
  Fishes, 143, 158
  Molluscs, 160
  Nemertines and Turbellaria, 168
  Oysters, 157
  Polyzoa, 163
  Protochordata, 160
  Protozoa, 173
  Sponges, 158, 172
  Variation, 176
Punctaria latifolia, 105
Purpura lapillus, 110
Pycnogonum littorale, 112, 207
Pygospio elegans, 630
— *seticornis*, 630

R

Raja, host of *Calicotyle*, 497
Ralfsia verrucosa, 105
Ramsay, L. N. G. On *Leptonereis glauca* Clpde., and the Genus *Leptonereis* Kinberg, 244
Raniceps raninus, 344
Rate of growth in marine invertebrates, 312
Rees, O. M. On *Eloactis mazeli*, 70
— Contributions to the Comparative Anatomy of some British Actiniae, 521
Report of the Council, **1912**, 123 ; **1913**, 395 ; **1914**, 647
Restitution masses formed by dissociated cells of Hydroids, 440
Rhina squatina, host of *Pseudocotyle*, 497

Rhipidocotyle minima, 472, 492, 498, 499
— *viperae*, 472, 493, 498
Rhizosolenia styliformis, distribution of, 518
Rhodymenia palmata, 105
Rhombus laevis, 358
— *maximus*, 358
Rhynchonella cynocephala, 296
Ritchie, J. R. Note on Two Unrecorded Plumularian Hydroids from the Plymouth Area, 260

S

Sabella curta. See *Melinna adriatica*
Sabella pavonina, rate of growth in, 316; of Plymouth and S. Devon coast, 641
Sabellaria alveolata, 108, 645
— *spinulosa*, 645
Saccocirrus sp., 596
Saccocoelium obesum, 471, 484, 500
Saccorhiza (*Laminaria*) *bulbosa*, rate of growth, 326
Sacculina carcini, 111
Sagartia carlgreni, 530, 533
— *milmani*, 528, 529, 533
— *miniata*, 106, 522, 535
— *nivea*, 523, 535
— *ornata*, 107, 526, 535
— *sphyrodeta*, 530, 533, 535
— *troglodytes*, 523, 534
— *undata*, 106, 524, 534
— *venusta*, 523, 535
— *viduata*, rate of growth, 314; 522, 523, 524, 534
Sagartidae, 521; comparative table of British species, 534
Salmacina Dysteri, 644
Salmo trutta, host of *Derogenes*, 487, *Bunodera*, 487
Saxicava rugosa, 111
Scalibregma inflatum, 640
Scalisetosus assimilis, 612
— *communis*, 612
— *pellucidus*, 612
Sclerocheilus minutus, 640
Scolecolepis fuliginosa, 629
Scolecolepis Girardi, 628
— (*Laonice*) *cirrata*, 629
— *vulgaris*, 628
Scoloplos armiger, 627
Scomber scomber, 349, 467; host of *Pharyngora*, 478, *Hemiurus*, 485, *Lecithocladium*, 485, *Octocotyle*, 496
Scophthalmus norvegicus, 359
— *unimaculatus*, 359
Scrobicularia plana, 110
Scrupocellaria reptans, 108; rate of growth, 317
Serpula vermicularis, rate of growth, 316; at Plymouth, 643
Serranus cabrilla, 392; host of *Helicometra*, 477, *Lecithaster*, 486
Sertularia pumila, 106
Sexton, E. W. On *Anthura gracilis* (Montagu), 236
Sigalion mathildae, 614
Siphonostoma typhle, host of *Podocotyle*, 473, *Acanthochasmus*, 488
Sipunculus nudus, 108
Solea lascaris, 361
— *lutea*, 361
— *variegata*, 361, 392; host of *Zoogonoides*, 483
— *vulgaris*, 361; host of *Zoogonoides*, 483, *Derogenes*, 487
Solenomya togata, ciliation of the gill of, 40; mode of feeding in, 38
Sparus centrodontus, host of *Steringotrema*, 480, *Zoogenus*, 483, *Hemiurus*, 484, *Derogenes*, 487
Spatangus purpureus, development of, 14
Sphacelaria cirrhosa, 105
— *plumigera*, 105
Sphaerodorum minutum, 626
Sphaeroma serratum, 111
Sphaerosyllis erinaceus, 597
— *hystrix*, 597
— *ovigera*, 597
Spinther miniaceus, 607
Spio filicornis, 630
Spiophanes bombyx, 629
Spirorbis borealis, 108, 644
— *spirillum*, 645
Sponge spicules, method of separating, 509

Staurocephalus ciliatus, 622
— *pallidus*, 622
— *rubrovittatus*, 622
Stephanochasmus caducus, var. *lusci*, 469, 477, 501
— *cesticillus*, 469, 477, 498
— *pristis*, 469, 501
Steringotrema cluthense, 470, 478, 502
— *divergens*, 470, 480, 499
— *pagelli*, 470, 480, 497
Sthenelais boa, 614
— *limicola*, 614
Stilophora rhizodes, 105
Streblonema faciculatum, 105
Styelopsis grossularia, 112
Stylarioides (Trophonia) plumosa, 641
Stypocaulon scoparium, 105
Sycon compressum, 106
— *coronatum*, 106; rate of growth, 314
Syllis Armandi, 600
— (*Ehlersia*), *cornuta*, 603
— *gracilis*, 603
— (*Haplosyllis*) *spongicola*, 603
— *hyalina*, 601
Synapta inhaerens, 611
Synaptobothrium caudiporum, 471, 486, 498, 499, 500
Syncoryne, rate of growth, 313
Syngnathus acus, 340; host of *Podocotyle*, 473
— *rostellatus*, 340

T

Tapes decussatus, 111
— *virgineus*, 111
Tealia coriacea, 107
Tellina tenuis, 110
Temora longicornis, experiments in keeping, 560, 564
Terebella (*Lepraea*), *lapidaria*, 633
— *sp.*, 107
Terebellides Strœmi, 636
Terebratula diphya, 296
— *janitor*, 296
Teredo navalis, rate of growth in, 320
Tergestia laticollis, 470, 483, 497
Tergipes despectus, 323
Tetrastemma sp., 107
Thalassiosira gravida, in artificial sea-water, 417; distribution of, 520
— *Nordenskiöldii*, distribution of, 520
— *sociale*, distribution of, 520
Thelepus cincinnatus, 635
— *setosus*, 635
Thyone raphanus, 229, 232
Tomopteris helgolandica, 618
Trachelifer, observations nouvelles, 194
Trachinus draco, 113, 377; host of *Derogenes*, 487, *Rhipidocotyle*, 493, *Microcotyle*, 497
— *vipera*, 377; host of *Lecithaster*, 486, *Derogenes*, 487, *Derogenoides*, 487, *Rhipidocotyle*, 492
Trachurus trachurus, host of *Tergestia*, 483, *Hemiurus*, 485, *Lecithaster*, 486, *Derogenes*, 487
Trachydermon cinereus, 108
Trematode parasites of fishes from the English Channel, 466; list of species, 469, 497
Trivea europea, 110
Trigla gurnardus, host of *Hemiurus*, 484, *Derogenes*, 487, *Rhipidocotyle*, 492, *Prosorhynchus*, 495
— *hirundo*, host of *Synaptobothrium*, 486, *Derogenes*, 487, *Rhipidocotyle*, 492
— *pini*, host of *Helicometra*, 476, *Hemiurus*, 484, *Lecithaster*, 486, *Derogenes*, 487, *Rhipidocotyle*, 492
Trochidae in Cardigan Bay, 114
Trypanosyllis caeliaca, 600
— *zebra*, 599
Tubularia larynx, rate of growth, 313
Tunicata, rate of growth, 324
Turbanella hyalina, 595
Turbellaria of Cardigan Bay, 106
Twin gastrulae and bipinnariae of *Luidia sarsi*, 577

U

Ulva latissima, 105; used in diatom cultures, 428

V

Verruca stroemia, 111
Volsella barbata, 110

W

Walton, C. L. The Shore Fauna of Cardigan Bay, 102

— The Distribution of some Littoral Trochidae and Littorinidae in Cardigan Bay, 114

Walton, C. L., and Rees, O. M. Some Rare and Interesting Sea Anemones from Plymouth, 60

Z

Zanclea implexa, 106

Zeugopterus norvegicus, host of *Podocotyle*, 473

Zeugopterus punctatus, 113, 359; host of *Helicometra*, 476, *Hemiurus*, 484, *Lecithaster*, 486

Zeus faber, 350; host of *Stephanochasmus*, 477, *Zoogonoides*, 483, *Synaptobothrium*, 486, *Lecithaster*, 486, *Derogenes*, 487

Zimmermann, K. Habit and Habitat in the Galatheidae: a study in adaptation, 84

Zoaeae, experiments in keeping, 559

Zoogonoides viviparus, 470, 483, 498, 499, 502

Zoonogenus vividus, 470, 483, 497

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